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ABSTRACT

The 50 papers in this collection from the 1980 ADCIS conference address topics ranging from coverage of large scale computer-based education (CBE) systems to specific single-purpose applications. The conference papers are presented in the following categories: Special Interest Group for the Handicapped; Mini-Micro Special Interest Group; Special Interest Group for Computer-Based Training; Elementary, Secondary, Junior College Special Interest Group; National Consortium for Computer-Based Music Instruction; Health Special Interest Group; National Consortium for CBE in Home Economics; Designing Instruction in the Basic Skills for Use with Micro Computer Technology; and PLATO Users Group. An author index is provided, and descriptions of 26 additional projects are attached. (MER)

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FOREWARD

The theme, "Computer-Based Instruction: A New Decade," is a reflection of the advent of the 80's and the recent impetus given CBE by the revolutionary popularity of personal computers. As one notable colleague put it, "We are experiencing the kind of revolution in CBE which we hoped for ten years ago." To all appearances the kind of future for CBE which many ADCIS members envisioned is, finally, a reality.

The papers contained in this volume are appropriately representative of much of the thinking about CBE for the new decade. Papers included cover a wide range of topics from large-scale, dedicated CBE systems to some specific single-purpose applications. They describe many of the CBE applications which are on the cutting edge. To further enhance the timeliness of this volume, the 1980 Proceedings includes the Project Reports which truly describe the latest state-of-the-art. It is hoped that individually and collectively the papers in this year's Proceedings will provoke more inquiry into the potential of CBE for the New Decade.

A special note of thanks is due those who worked so hard to insure the success of the 1980 Program. Mary Broman, this year's host, has been no less than sensational in her efforts, enthusiasm, and dedication. Mary, who was new to ADCIS at this same time last year, has made a tremendous contribution for which we should be grateful and proud. The SIG Chairpersons assumed a major role in planning their portions of the program this year and gave greatly of themselves in cooperating with the Program Chariman. For all the assistance, interest, and support provided by many ADCIS members, I am most appreciative.

James E. Eisele
1980-81 Program Chairman

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A STUDY OF FACTORS AFFECTING THE SUCCESS OF COMPUTER-ASSISTED INSTRUCTION IN SELECTED COLLEGES AND UNIVERSITIES

Ann S. Potts

Florida Atlantic University

ABSTRACT

The purpose of this study was to identify the factors affecting the success of computer-based instructional programs in selected colleges and universities. During this process related questions of interest were posed and answered: What are the greatest problems or obstacles encountered in establishing a CAI program? What incentives are offered to faculty members who develop CAI curriculum materials? Do programs stand better chances for success when initiated by top level administrators? Are faculty attitudes deemed important factors in successful implementation?

In addition to identifying success factors and answering these questions, the study resulted in the following conclusions: (1) Faculty support is the most important factor contributing to a successful CAI program; (2) the greatest problem in establishing CAI is a financial one; (3) incentives are not necessary for involving faculty in the development of extensive CAI programs, even though most schools offer them, at least in token form; (4) computer-based education programs do not necessarily have better chances for success when initiated by upper-echelon administrators; and (5) academic computing directors and CAI administrators deem faculty support as the most important factor determining the success of CAI programs.

Introduction and Purpose

Computer-assisted instruction,[1] in existence for almost twenty years and still ignored by many educators, is looming ever larger on the educational horizon--to the extent that every administrator should be seeking the means to make himself or herself knowledgeable about its capabilities. Similar prognostications were made as much as a decade ago, but while these were admittedly premature, multifarious research and ensuing advances in computer technology, coupled with more software being engineered and made available, have now brought computer-assisted instruction into the realm of feasible, cost-effective instructional techniques.

While some educators are cautious, conservative, and sometimes inexorable in the matter of adopting or adapting to non-traditional instructional methods, there are those who are seeking new methods and apparatus to improve the teaching/learning process and to attain desired goals and objectives. Computer-assisted instruction is now an instructional choice for the innovative and concerned educator, but it is one which needs to be made wisely. Although a vast amount of literature is available to inform the administrator or instructor about the capabilities of computer-based instruction and its varying

[1]In this report "CAI" refers to all instructional uses of the computer and is used synonymously with "computer-based education" and "instructional computing".

degrees of effectiveness, the factors affecting the success of programs in colleges and universities have not been systematically identified and described. The purpose of the study reported here has been to identify and describe those factors and thus answer the prime question behind the research: What are the factors that contribute most to the success of CAI implementation? Other questions were posed because their answers might substantiate the reply to the first one. What are the greatest problems or obstacles encountered in establishing a CAI program? What incentives are offered to faculty members who develop CAI curriculum materials? Do programs stand better chances for success when initiated by top-level administrators? Are faculty attitudes deemed important factors in successful implementation?

Procedures

Answers to the aforementioned questions were sought through an examination of CAI programs in fourteen colleges and universities conducted primarily by means of a fifteen-question survey instrument which produced a 100 percent response from CAI directors and program administrators. Information received from these respondents to the questionnaire was augmented by personal interviews with half of them in their schools. A case study for each institution was compiled from the collected data. Additionally, the responses to each question on the survey instrument were analyzed, summarized, and codified in table form.

The subjects for the study were institutions of higher education selected from the Academic Computing Directory, a 1977 list of 370 exemplary schools presently using computers for learning and teaching. In brief, the criteria applied in making selections include a cross-section of types of universities and colleges (public and private, a military school, a school for women, a school for blacks, and a school for the deaf) and sizes (over 10,000 and under 10,000), accessibility for on-site interviews and observations, and utilization of academic computing in several disciplines rather than in one or two.

Findings

The findings of this study, derived from questionnaire response data and additional facts collected during personal interviews, have been presented in detail through case studies and tables. A brief summary of them follows:

1. Faculty members and computer specialists, not top administrators and department chairpersons, are the ones most often responsible for a school's initial involvement with CAI.

2. The majority of schools do not encounter open opposition from faculty or organizations in establishing CAI.

3. The range of faculty members presently using CAI as an instructional tool or technique extends from 3 percent to 50 percent, with a mean of 21.4 percent.

4. None of the fourteen institutions surveyed has had to reduce its instructional personnel due to CAI usage.

5. The majority of schools surveyed offer some incentive to faculty members for developing and using CAI programs. Conversely, the two schools which have the largest percentages of faculty utilizing CAI offer no incentives at all--and these same schools are employing some form of instructional computing in every department.

6. Eight institutions have conducted studies comparing the effectiveness of CAI with traditional instruction; six have not. Although reports on these studies were not always available, there were indications in responses to other questionnaire items that CAI was found to be effective in these institutions. All of the eight institutions are continuing with CAI in numerous disciplines and none plans any curtailment of programs; in fact, six of the eight are expanding their programs.

The future plans of eleven of the fourteen colleges and universities include expansion of CAI facilities and programs. Three intend to maintain the status quo and not one plans curtailment of CAI programs.

7. Computer literacy courses are offered by twelve of the fourteen colleges and universities, most often as an elective, although in one school it is required of all students.

8. The two most frequently mentioned problems or obstacles encountered in establishing CAI are financial or faculty related ones, financial being cited ten times, faculty eight times. Lack of administrative support was listed by four schools, a lack of courseware by one, and a problem in development of courseware by one. Nine institutions indicated more than one problem.

9. The most frequently mentioned factors contributing to the success of CAI program implementation concern faculty. Their contributions to success (cited in part by nine of the fourteen schools) are

initiative, enthusiasm, leadership, open mindedness, curiosity, and dedication, but faculty members making these contributions are quantified by program administrators with terms such as "a few," "a nucleus of," and "some." Tying for second place as success factors were administrative support and computer center personnel dedication or support, each cited three times. Good computer resources and external assistance or resources were listed by only two schools. Eight institutions listed more than one contributing factor.

10. Only five of fourteen schools stated a dollar amount budgeted for instructional computing for the current school year. Among them the range was from $15,000 to $800,000, the mean being $317,000. These are not significant figures when two other factors are taken into consideration--the diversity in sizes of schools surveyed and the fact that many instructional computing programs are developed with external funds.

11. Of CAI modes currently in use, drill and practice is the most commonly used, with all fourteen institutions reporting its presence in their programs. Tutorial and problem solving modes were reported in use in all except one school. All except two of the fourteen schools employ simulation, and nine are using graphics.

12. A majority of the colleges and universities surveyed are producing the majority of the CAI curriculum materials which they use. Eight of the fourteen schools produced 60 percent or more of their materials; two produced 100 percent. The mean production for these schools was 79.38 percent. The mean for all schools surveyed was 60.75 percent. The second source of curriculum materials--or courseware, as they are more commonly termed--is a commercial concern. The least used source is another college or university. For all schools surveyed, the breakdown on sources of courseware is as follows:

(a) Produced within the school where used: 63.75%

(b) Purchased from commercial concerns: 21.75%

(c) Acquired from another college or university: 14.50%

The courseware is being developed within institutions by teams of instructors and computing personnel and by individual faculty members. In the majority of schools which utilize both teams and individuals to produce programs, the CAI administrators deemed the team development approach to be more satisfactory.

13. Five of the fourteen schools are using CAI in every department. In the other nine schools, the range of departments utilizing CAI extends from three to eight. Mathematics and computer science departments employ it more than other disciplines, with thirteen of fourteen schools reporting its use in both. Twelve institutions list physical science departments as CAI users, ten list social sciences, nine humanities, and seven biological sciences. Education departments are cited less frequently than any other discipline as CAI users.

Conclusions

The conclusions of this study have resulted from an analysis of findings from the questionnaire response data and personal interviews combined with observations made during the review of the literature. Based on evidence contained in these sources, the conclusions also provide answers to the questions posed at the beginning of the study.

Faculty support is the most important factor contributing to a successful CAI program. Therefore, the computing center director or whoever assumes responsibility for inaugurating CAI, should be a person who can help stimulate interest among faculty and inspire them to try instructional computing. Once involved, faculty members usually are converted into enthusiastic supporters.

The greatest problem in establishing CAI is financial. Thus, it is advisable to seek external sources--i.e. industry or government--for the funding of costly new programs. This is what many colleges and universities have done already and are continuing to do.

Incentives are not necessary for involving faculty in the development of extensive CAI programs, even though most schools offer them, at least in token form. Some of the most effective instructional computing programs and most responsive faculties are found in schools which offer no incentives.

Computer-based instructional programs do not necessarily have better chances for success when initiated by upper-echelon administrators. However, administrative support is vital to the life of the program. It is ranked high as a factor contributing to successful CAI.

Academic computing directors and CAI administrators deem faculty support as the most important factor determining the success of CAI programs.

The dedication and support of computer center personnel is as important to the success of CAI as is the support of the administration. Because computer

professionals (and even computer hobbyists) are an enthusiastic cult who believe strongly in the value of their technology, their dedication and support in the establishment of CAI can be assumed.

Recommendations

The recommendations which follow stem from observations made during the entire course of the study and from all of the sources of data. Although not categorized, they are basically of two sorts. Three recommendations are made to administrators and/or CAI researchers, developers, and users in higher education. Two are recommendations for future research in the area of instructional computing.

Efforts should be made to establish a national office to coordinate what is happening in the instructional computing arena. Those presently involved in research, development, and use could be the most influential in working toward this end. Through their professional organizations--both computer oriented and discipline oriented--they could gain the attention of legislators who could assist in the creation of a national coordinating agency. Heretofore, there have been multifarious projects and programs to develop the hardware, software, and courseware. While diverse and unrelated research and development projects have provided a rapid means to advanced developments, they also have resulted in a variety of equipment and materials which are not always interchangeable nor even adaptable to other systems. Therefore, much good CAI curriculum material cannot be passed around because it is not compatible with certain systems. If future planning, development, and evaluation, along with dissemination of information, could be accomplished through the auspices of a federal agency, it could provide some standardization and a central source of information about all aspects of computing. Presently there is not a single source for finding out about recent developments; many sources have to be tapped by interested persons.

With the computer now pervading every aspect of life in today's society, the need for computer literacy at all educational levels is going to become more intense and may someday be as basic as reading or writing skills. For this reason, all educational administrators are urged to seek ways to obtain adequate computer facilities in order to provide literacy courses in their schools; to investigate curricular materials for teaching computing skills to enable students to write programs, solve problems, and retrieve data; and, most immediately, to make themselves and their instructional staffs informed about the impact computers are already making on society and education.

Assuming that the immediately preceding recommendation could be followed, it is further recommended that college and university administrators implement computer literacy courses and require them of all students to prepare them to work in a society increasingly computer oriented. Those students seeking advanced degrees in educational administration should be required to take additional computing courses to provide them with an even better conceptual understanding and enough technical knowledge to plan for hardware, software, and the necessary manpower to implement a system.

Computer literacy courses are extremely varied in content and form. Some schools teach programming and the use of the computer under this course name while others teach about the computer and its capabilities under the same title. A future study might attempt to determine the nature of computer literacy courses in a sampling of schools and assess their value in the lives of recent graduates.

Finally, there is an interesting question for which research should provide the answer at some time in the future. Do extensive instructional computing facilities in a college or university help attract outstanding students and/or faculty members? A study that could supply the answer should be of value to those who contemplate initiating a system or adding to their present one.

IMPORTANT CRITERIA TO CONSIDER FOR EVALUATING INSTRUCTIONAL SIMULATIONS

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ABSTRACT

This paper discusses various criteria necessary when evaluating simulations. The type of simulation discussed is restricted primarily to simulations used with computer-based education. However, much of what is said about simulations in CBE (computer-base education) also pertains to simulations used with other instructional mediums.

The evaluatory criteria, were for the most part, obtained and conglomerated from a broad literary survey of the work done with the evaluation of instructional simulations. This paper also elaborates on the advantages and disadvantages of using a computer to present a simulation. Such factors are individualized instruction, vast record keeping facilities, and reproducibility of previous simulated experiences.

Definition

A simulation is either an act or an entity that represents reality. In other words, a simulation provides an artificial environment and an artificial experience for the participants. But, this environment and experience, even though they are artificial, represent or feign reality. The representation of a particular aspect of reality gives the user a clearer understanding of the reality that it represents.

Evaluation

The evaluation of simulations should cover three broad areas. These areas are content of the simulation, structure of the simulation and use or implementation of the simulation (Elder, 1975). The first area, simulation content, includes an evaluation of not merely subject matter content, but also validity studies. The content area evaluation is an extremely important aspect of simulation evaluation. However, an evaluation of this sort would be very extensive and require a good understanding of the subject matter represented in the simulation. The author of a simulation should, at some point, always evaluate the content of their simulation. I will mention a few considerations to be aware of when evaluating simulation by content, but this paper will concentrate mainly on the areas of validity, structure, and use.

Evaluation - Validity

The purpose of validity studies is to evaluate the degree of reality represented in the simulation. The task of evaluating a simulation's validity should include an examination of the simulation variables and rules to determine if they adequately represent the real-life model. It is possible for some real-life variables to be eliminated or exaggerated in the simulated model as long as the significant aspects of the simulated process are still credible to the user. All simulations should be compared with other teaching methods to determine if they adequately teach the student to deal with the real-life situation. These are evaluative tests that every simulation author, and most instructors who use simulations, should conduct. After the validity tests are conducted, the educator should examine the results and make any appropriate changes in the simulation model. As with any educational method, there should be a continual evaluation of the model, and then a restructuring of the model according to the results of the evaluation.

IMPORTANT CRITERIA FOR INSTRUCTIONAL SIMULATIONS

A specific simulation will be valid to differing degrees depending on the target group using the simulation. This is because what may be valid to one group of users may not be valid to other groups. Variables in group structure that can effect the validity of a simulation include cultural composition, age, educational background, philosophical orientation to the simulation, and administration of the simulation. For this reason, every educator using simulations, whether they developed the simulation or not, should conduct evaluation studies to determine the validity of the simulation being used with a particular target group.

Evaluation - Structure

Seven aspects of simulation structure evaluation will be discussed. These aspects are simulation objectives, simulation credibility, symmetry of a simulation, synchonization of a simulation, feedback or reinforcement in simulations, relationship between chance and skill involved in simulations, and the flexibility of simulations.

Learning Objectives

During the initial phases of constructing a simulation, learning objectives should be defined. A definition of what the simulation is supposed to teach and for what kind of group it is being written should be provided. In most situations, it is desirable to inform the user of the learning objectives at the start of the simulation. In cases where learning objectives are not stated at the beginning of the simulation, the student may actually learn some wrong skills or processes. Establishing learning objectives will always aid the evaluator in conducting validity tests.

Credibility

Credibility is another important aspect of simulation structure (Elder, 1975). The simulation should at all times remain plausible to the user. One of the advantages of using simulations is that the instructor can present the student with a controlled environment. However, it is important to insure that this environment is credible to the user. A simulation may not necessarily represent all of the varibles in real-life, but it must represent all of those variables and relationships that are significant in terms of the learning objectives. A simulation that does not represent all of the significant variables will not be credible for the user. On the other hand, a simulation that represents considerable more variables than are significant may appear too complex and unmanageable for the student. The simulation author must determine which variables in the real-life model are significant and necessary for the learning objectives, and then represent them validly in the simulation.

Symmetry

Symmetry refers to the common experiences of students using the same simulation (Elder, 1975). The simulation should provide every user with the ability to reproduce, with reasonable accuracy, an earlier or specific experience. If the simulation variables, relationships, starting conditions, objectives and other parameters remain constant, the student is less likely to become confused and lost. Being able to reproduce a previous experience is an important aspect of learning. Reproducibility factors play a role in maintaining something in memory. Simulations should not allow wide fluctuations in outcomes, especially if the user is reacting consistently. Sometimes symmetry may not agree with a real-life situation. However, unless the major learning objective is to teach wide fluctuations, this should not occur. Being able to reproduce previous results is too important of a learning aid to be eliminated.

Flexibility

Symmetry should not be confused with flexibility. A flexible simulation will allow a student to move about in the simulation according to their own decisions. In other words, they permit the student to control the flow of the simulation. Flexibility and symmetry need not be mutually exclusive properties. A simulation can allow the student to determine his/her movement throughout the simulation and at the same time allow a student to reproduce earlier experiences. This combination of symmetry and flexibility is the most desirable. However, the author must be careful to make sure that all symmetry and flexibility factors reflect the learning objectives and the real-life situation.

Synchronization

One advantage of using computers to simulate experiences is that the time reference can be easily changed. Computer time can be sped up or slowed down. A simulation of a genetical laboratory process can produce the results of the experiment almost instantaneously while a real-life experiment will take days, or months, to produce the same results. Likewise, a process that takes place in micro-seconds can be slowed down so that it can be studied in greater detail and perhaps at a pace selected by the student. Although

these capabilities are definately advantageous, the simulator developer must be careful how they are used.

When a time scale is changed, there is always the chance that the student will be confused due to asynchronization (Elder, 1975). Therefore, the pre-simulation debriefing period should include an explanation of the time scale used in the simulation. In complex simulations, multiple time scales may be necessary. This will be even more confusing for the student and should be used with the appropriate care.

Simulations which involve more than one student will complicate the situation even further. If these students must interact with one another they may each be interacting on their own time sclae and will not be sychronized to the other person's time scale. This is very unsatisfactory, and should not be incorporated into a simulation. The simulation would have to be structured in such a way as to insure that two students would not interact if they were on differing time scales, thereby eliminating the problems of asynchronization.

Ideally, in any one simulation the time scale will remain constant for every participant throughout the duration of the simulation. If, when developing a simulation, the author decides that the learning objectives of the simulation require the use of changing time scales, than they will have to be used. In that event, the situation should be thoroughly and clearly explained to the students prior to the beginning of the simulation.

Feedback

Feedback is another important structural characteristic of simulations and should be considered during an evaluation. Once again, this structural feature should be appropriate in terms of learning objectives and the real-life situation. The ideal feedback need not be a yes/no comment. If a student's response in a real-life situation would invoke an action from the environment, from another person, or from a piece of machinery, than a representation of that action should be incorporated in the simulation. So, for a given student decision, s/he may not necessarily receive any yes/no comment. A responding action from something in the simulated system may be sufficient.

Chance/Skill

In some simulated experiences, chance plays a factor in determining an outcome or movement within the situation. If this is the case in the real-life model, and if the concept of chance is important for the learning objectives, than the author must be sure to include them in the simulation. The simulation writer must carefully determine which variables are determined purely by chance, which are determined purely by skill, and which variables can be determined partly by both factors (Colemen, 1967). For those variables which can be determined by both chance and the skill of the participant, the author must also determine how much of a role both chance and skill play in controlling the variable.

Evaluation - Implementation

The last area of simulations to be evaluated is the use, or implementation, area. Factors that fit into this category are the compatibility of the simulation with the curriculum, pre-simulation and post-simulation discussion, the ease with which the technical aspects of the simulation can be manipulated, the administrative ease and control for the instructor, and factors which compare simulation use with other types of instruction. Factors that could be included in this last category are time on task, cost effectiveness, and safety factors.

Curriculum Compatibility

Curriculum compatibility is a evaluation that every instructor who uses a simulation should determine before administering the simulation. Elder states that simulations cannot stand alone He says,

> "Simulations may be used to summarize, integrate, and illuminate previous instruction or to provide a common experience for reference in subsequent instruction. Without other instruction, however, participating in a simulation is an incomplete learning experience."[1]

If preliminary knowledge is required before the simulation can begin, than it is obviously important for the instructor to work that instruction into the curriculum. A simulation that was written for the learning objectives of a specific course, probably will not be effective for a course which has a different set of learning objectives. Therefore, both the course curriculum and the simulation may have to be altered or adjusted everytime a simulation is used.

Debriefing

Pre-simulation and post-simulation debriefing sessions are important for the learning process. These debriefing sessions can occure either off-line or on-line. Pre-simulation debriefings include

informing the student of the simulation learning objectives, and how to conduct the simulation. Post-simulation debriefings should include an explanation of what happened during the course of the simulation and why it happened. The post-simulation discussion should also raise questions of the students, and answer any questions or problems they may have encountered during the simulation.

Manageability and Administration

A simulation which is difficult to use is bound to be a less effective teaching tool than one that is easier for the student to manipulate. The objective of most simulations will not be the mechanics of operating a computer terminal, so as little of the student's time and effort as possible should be spent working on that aspect of the simulation. The simulation should not only be easy for the student to manipulate, but also for the instructor. Simulations that require complex and timely procedures on the part of the instructor will probably not be used as often or as effectively as they should be. Computer-based education simulations often enable built in aids for the instructor. Some examples of these aids are detailed record keeping, high speed of calculation, and numerical accuracy. These aids should be incorporated into simulations, if they are needed, but at the same time these administrative procedures should be easy for the instructor to access and interpret (Elder, 1975).

Comparison with Traditional Methods

The last evaluative category includes a comparison of the use of simulations as compared to the teaching of the same concept in traditional situations. Factors that will be considered in this category are cost, time, and safety factors. The development cost of simulations is often very high. Therefore, one must justify this cost by showing that the simulated process is taught significantly better via computer simulation than via other less costly methods. Time considerations may be one factor why a process is taught via computer. A situation that involves time consuming procedures or a period waiting for the results can be presented in much quicker time span via a computer simulation. Computer time can also be slowed down so that the student can observe a process that might occur quickly in a real-life situation. Another factor is that a computer simulation may provide a safer environment for a person to learn as opposed to many laboratory or clinical situations. Some situations would be impossible to present other than via a simulation becuase of factors such as spacial requirements or the complexity of the situation in real-life.

In conclusion, several important criteria have been presented which should be useful for evaluating instructional simulations. These criteria should be considered not only by authors of simulations, but also by instructors using simulations developed by another person.

FOOTNOTES

[1] Charles D. Elder, "Problems in the Structure and Use of Simulation", Gaming-Simulation: Rationale, Design, and Applications. Greenblat, Cathy S.; Duke, Richard D., (eds.), (John Wiley & Sons, 1975), p. 302.

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HOW COMPUTER-BASED INSTRUCTION WAS COST JUSTIFIED IN THE FEDERAL AVIATION ADMINISTRATION

JOHN A. BUCK AND PATRICIA S. BEARDSLEY

FEDERAL AVIATION ADMINISTRATION

ABSTRACT

An approved study of the feasibility of converting a substantial portion of the Federal Aviation Administration's large training system to computer-based instruction (CBI) showed that any of several CBI configurations would be cost beneficial. A system of CBI terminals at multiple, geographically separated sites was recommended.

BACKGROUND

The Federal Aviation Administration (FAA), a Government agency with about 55,000 employees, promotes the safety and growth of the aviation industry. The FAA's major occupations such as air traffic controller, airspace equipment technician, flight inspection pilot, etc., are unique to the agency and require it to maintain a substantial training system. That system includes the FAA Academy, a centralized training school located in Oklahoma City which employs about 700 instructors.

The FAA has been exploring the potential of CBI since 1973 at the FAA Academy and at certain operational field facilities around the country and in Europe. As part of that exploration, a series of studies were begun in 1977 to examine the possibility of conducting major portions of the FAA's training via CBI. We reported on the first of those studies, a Requirements Analysis, at last year's ADCIS conference in San Diego.(1) That paper contains a detailed time-phased flow chart of the study's activities.

The second study in the series entitled "Feasibility Study of Computer-Based Instruction" was completed and approved in August 1979. This study was written "from scratch" because no comparable studies by other organizations could be found. The purpose of this paper is to share: the results of that study, some possibly innovative techniques for cost analysing computer-based instruction, some recommendations for further study, and FAA's general conclusions and plans regarding CBI.

FEASIBILITY STUDY METHODS AND RESULTS

In the earlier Requirements Analysis Study about 40 FAA "high potential benefit" courses were selected for analysis in the Feasibility Study. These courses provided a basis for the Feasibility Study. Although other courses in the FAA training system could also be converted to CBI format, the figures shown in the tables below represent only those 40 courses.

Five alternative strategies for handling the 40 courses were identified and analyzed. Although many alternatives are possible, the following alternatives were considered representative of the range of possibilities.

1. Status Quo
2. Manual Individualized
3. CMI at FAA Academy Only
4. CMI/CAI at FAA Academy Only
5. CMI/CAI at FAA Academy at certain FAA operational facilities around the country (referred to as the "Remoted Training" Option).

To facilitate analysis three benchmark courses whose instructional

(1) "Requirements Analysis and Feasibility Study of Computer-Based Instruction for the Federal Aviation Administration, Department of Transportation," Buck, Bullard, Fagan; ADCIS Proceedings 1979, Vol. 2, pp. 331-338.

characteristics were representative of the 40 courses were examined in considerable depth. Careful estimations were made as to how each course is or would be taught under each delivery alternative, and those estimations were uniformly projected onto each of the other 40 courses with the help of a small computer program written for that purpose. The idea was to compare the relative costs of each option rather than trying to pinpoint exact costs.

The estimated start-up costs derived for each option are as high as $8.8 million, assuming conversion of the full 40-course curriculum over a four-year period, as is shown in Table 1. Table 2 shows the estimated recurring costs for each option and shows the anticipated savings in comparison with the present methods of training. Those savings are as high as $6.7 million per year. Except for student salaries, the dollar savings shown are hard (i.e., directly recoverable) savings. Student salaries savings were calculated because they are an indicator of the value of course time savings; they may also be recoverable over the long term. Table 2 also shows expected position savings. These represent saved instructor positions which could be assigned other work or removed from current authorized staffing. The FAA requires its instructors to rotate out of the FAA Academy at pre-set intervals, providing an administrative mechanism which could facilitate reductions in staffing levels without using burdensome reduction-in-force (i.e., lay-off) procedures.

Table 3 shows the estimated break-even points for each of the options. In the Remoted Training Option the breakeven point could be reached in two years or less. Table 4 demonstrates that new course development would not pose new, untoward expenses in any of the options except the Manual Individualized alternative. The CBI options would be slightly more expensive than current methods if student salaries are not considered.

KEY (POSSIBLY INNOVATIVE) COSTING TECHNIQUES

1. A number of costing subcategories were used to develop the estimates shown in the tables at the end of this paper. For instance, the recurrent cost categories included instructor contact, preparation, and course maintenance times; student salaries while taking courses and their travel and per diem costs; direct clerical and administrative overhead; off-line training materials; and hardware, software, and telecommunication costs. Initially, development of "traditional" summary statistics such as "cost per student hour" was attempted. However, such general figures were found to be too broad for meaningful analysis and were not used.

2. To estimate equipment costs for the three CBI alternatives a configuration of terminals was projected for each option. A price range for the configurations was determined by finding how much it would cost for each of three leading CBI vendors to support the configuration. To ensure conservative estimation, the highest cost figure was used in each case.

A question arose as to whether the proposed "typical" equipment configurations could support the heavy student load represented by the 40 courses. The question was answered by developing a formula for determining how many "terminal equivalents" each course needed. The terminal equivalents (T.E.) for all the courses were totalled, and if that total did not exceed the actual number of terminals projected for the configuration, the configuration was judged to be large enough to handle the student load. The formula used for T.E. is:

$$\text{T.E.} = \frac{(\text{CMI hr/stu} + \text{CAI hr/stu})(\text{no. stu/year})}{(\text{trng days per year})(\text{hrs in trng day})(.7)}$$

Here "CMI hr/stu" and "CAI hr/stu" means the estimated number of hours which an average student would have to actually spend at a learning terminal doing CMI and/or CAI activities. The ".7" figure in the denominator is a queing factor which reflects the impossibility of achieving 100% usage of the terminals.

3. Another costing technique of possible general interest was the use of sensitivity analysis to identify the most important or crucial assumptions and estimates. That is, the estimation parameters built into the original computer program were altered by various amounts and the program rerun to test the effects on the overall cost and savings projections.

Somewhat to our surprise, the study's conclusions are relatively insensitive to a number of possible estimation errors. For instance, the three CBI alternatives would provide cost savings from instructor positions saved even if little or no reduction in course length was achieved. (The study's actual estimates of course reduction expected from CBI ranged from 11% to 50% depending on the particular course.) This finding increased our confidence in the soundness of the study's conclusions.

The most crucial expectation appears to be the assumption that instructors would be needed very little or not at all for "live," face-to-face instruction in major portions of the courses. This expectation appears reasonable based on FAA's experience and the experience of other CBI users.

SUGGESTIONS FOR FUTURE STUDY

1. Much of the existing literature on CBI cost benefits, including user studies as well as vendor literature, seems to emphasize the advantages to be gained from course length reduction. Too little attention has been given to the potentially tremendous savings from reduction in the instructor time. There seems to be even less concern about the best roles for an instructor in the CBI environment. We would very much like to see developed an in-depth definition of the learning conditions under which the instructor is the optimum learning resource and more discussion about the kind of activities an instructor should be expected to perform as a course manager.

2. CAI is another learning resource which could profit from better overview role definition. The study assumed in most cases that the amount of time students would spend doing CAI would be a little less than 10% of their total course time in the CBI mode; conversely, it assumed that most of the course time would be spent with off-line learning resources. This assumption was based on our experience and observations that CAI is the optimum learning resource only for the more difficult parts of a training course. Those parts that "students always have trouble picking up" are handled in a classroom mode by interactive discussion between the instructor and students.

The nature of this "interactive" instruction needs to be better defined so that a project manager responsible for developing or converting to interactive CAI format can guage, prior to in-depth course development, how much CAI will be necessary. CAI authoring can consume considerable resources which must be planned for and obtained far in advance of actual course development.

CONCLUSIONS AND FUTURE PLANS

The FAA has decided to adopt the "Remoted" option. Planning for broad development of CBI will be pursued using equipment and services which facilitate multi-site training.

Cost considerations aside, this approach is clearly advantageous in its potential non-quantifiable benefits as is shown in Tables 5 and 6. Further, there may be many additional cost benefits to be gained from CBI training locally developed by FAA field personnel. The FAA has had little experience with CBI in on-the-job and proficiency training. It plans to conduct test projects in the near future to provide an objective basis for cost analysis in this area.

The next step in the FAA's automated data processing (ADP) planning and justification process is the development of a System Proposal. This document, which leads into the procurement process after management approval, further develops the cost analysis of the option chosen in the Feasibility Study and defines a complete system.

After considerable debate, it has been determined that the CBI system will be "evolved" rather than described and procured on a one-time basis as is normally the case with ADP equipment. Under this strategy development of a few CBI courses will continue on the FAA's currently available CBI equipment. An Interim System Proposal will be prepared covering convesion and delivery of a number of courses with the highest potential payback. After the FAA has gained more experience in managing CBI courses, a Full System Proposal will be completed covering substantially more courseware.

HOW CBI WAS COST JUSTIFIED IN THE FAA

TABLE 1

RESOURCES - START-UP COSTS

	STATUS QUO ($M)	MANUAL INDIV. ($M)	ACADEMY CMI ONLY ($M)	ACADEMY CAI/CMI ($M)	REMOTED CAI/CMI ($M)
SALARIES	.0	4.8	4.2	4.6	4.8
ADP EQUIP & SITE PREP	.0	.0	1.7-3.1	1.8-3.2	2.5-3.5
NON-ADP EQUIP/SITE PREP	.0	.1	.1	.1	.2
TELECOMMUNICATIONS	.0	.0	.2	.2	.3
TOTAL	0.0	4.9	6.2-7.6	6.7-8.1	7.8-8.8
POSITION YEARS	0	127	108	122	127

TABLE 2

RESOURCES - RECURRING COSTS AND SAVINGS

	STATUS QUO ($M)	MANUAL INDIV. ($M)	ACADEMY CMI ONLY ($M)	ACADEMY CAI/CMI ($M)	REMOTED CAI/CMI ($M)
STUDENT SALARIES	12.5	9.6	9.6	9.5	9.5
TRAVEL & PER DIEM	6.6	5.7	5.7	5.6	4.5
INSTRUCTOR/SUPPORT SALARIES	4.4	4.4	3.1	2.2	2.4
SUPPLIES & MAINTENANCE	-	-	.2	.2	.2
TELECOMMUNICATIONS	-	-	-	-	.2
TOTAL	23.5	19.7	18.6	17.5	16.8
POSITIONS	135	138	94	68	73
DOLLAR SAVINGS		3.8	4.9	6.0	6.7
(EXCULDING STUDENT SALARIES)		(.9)	(2.0)	(3.0)	(3.7)
POSITION SAVINGS		-3	41	67	62

TABLE 3

AMORTIZING START UP COSTS

	MANUAL INDIV.	ACADEMY CMI ONLY	ACADEMY CAI/CMI	REMOTE CAI/CMI
DOLLARS				
TOTAL START-UP COSTS	4.9	7.6	8.1	8.8
ANNUAL SAVINGS-TOTAL	3.8	4.9	6.0	6.9
ANNUAL SAVINGS (EXCL. STUDENTS)	(0.9)	(2.0)	(3.0)	(3.9)
YEARS TO BREAK EVEN	1.3	1.5	1.4	1.3
YEARS (EXCL. STUDENTS)	(5.4)	(3.8)	(2.7)	(2.3)
POSITIONS				
POSITION-YEARS FOR START-UP	127	108	122	127
ANNUAL POSITION SAVINGS	-3	41	67	62
YEARS TO 'BREAK EVEN'	-	2.6	1.8	2.0

TABLE 4

RESOURCES - NEW COURSE DEVELOPMENT
Typical New Three Week Course

	STATUS QUO	MANUAL INDIV.	ACADEMY CMI ONLY	ACADEMY CAI/CMI	REMOTED CAI/CMI
SALARIES ($ '000)	112.5	121.8	96.6	102.6	102.6
(EXCL. TRYOUT STUDENTS)	(88.2)	(117.9)	(92.7)	(98.6)	(98.6)
POSITION-YEARS	2.5	3.4	2.7	2.8	2.8
INSTRUCTOR/DEVELOPER	2.3	3.2	2.5	2.2	2.2
EDUCATIONAL SPECIALIST	0.2	0.2	0.2	0.2	0.2
CAI AUTHOR				0.4	0.4

TABLE 5

EVALUATING OPTIONS - THE PROS

	STATUS QUO	MANUAL INDIV.	ACADEMY CMI ONLY	ACADEMY CAI/CMI	REMOTED CAI/CMI
AVOIDS CONSEQUENCES OF CHANGE	X				
CUT STUDENT'S TIME AND RELATED COSTS		X	X	X	X
BUILDS ON STUDENT'S BACKGROUND/ TRAINING		X	X	X	X
EASY COURSE MAINTENANCE & SECURITY			X	X	X
STANDARDIZED INSTRUCTION			X	X	X
CUTS INSTRUCTOR TIME & RELATED COSTS			X	X	X
HIGH QUALITY INTERACTIVE INSTRUCTION				X	X
CAPABILITY FOR HANDLING ADDITIONAL COURSES				X	X
STUDENTS OPERATIONALLY AVAILABLE					X
EASY TO HANDLE PEAK STUDENT LOADS					X
EFFICIENT EVALUATION BY FIELD					X
MAXIMUM TRAVEL/PER DIEM SAVINGS					X
MAY SUPPORT PROFICIENCY/FIELD GENERATED TRNG.					X

TABLE 6

EVALUATING OPTIONS - THE CONS

	STATUS QUO	MANUAL INDIV.	ACADEMY CMI ONLY	ACADEMY CAI/CMI	REMOTED CAI/CMI
NO ROOM FOR ADDITIONAL COURSES	X				
FY 1980 CONSTRAINTS CAUSING CANCELLATIONS	X				
STUDENT SCHEDULING MORE COMPLEX		X	X	X	X
PROVIDING FOR STUDENT INTERACTION DIFFICULT		X	X	X	X
COURSE DEVELOPMENT MORE DEMANDING		X	X	X	X
SUBSTANTIAL CONVERSION COSTS		X	X	X	X
LARGE INVESTMENT IN ADP EQUIPMENT/ TRAINING			X	X	X
NEED FOR CAI/CMI AUTHORS				X	X
MANAGEMENT OF MULTIPLE LEARNING CENTERS					X

User Guides, Evaluations and Developmental Workshops for CAI Projects

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Introduction

Documentation has traditionally been the bane of programmers and authors. One purpose of this paper is to suggest methods of handling this problem. The background to the development of Users Guides for CAI (Computer Assisted Instruction) is described and an overview of their introduction and dissemination is given. In addition, the paper describes how computerized records are utilized to monitor the effectiveness of CAI projects. Finally, the use of workshops or short courses as a method of encouraging the growth of future CAI projects is discussed.

To put the situation in perspective, it should be stated that the University of Tennessee at Chattanooga is a primary campus of the University of Tennessee. UTC is an urban institution having a total enrollment of 7,000 students, with 5,000 undergraduate.

In 1975, it was perceived by the UTC Administration that there was a need for student access to CAI materials in addition to the traditional exposure of computer languages. An Office of Academic Computing was initiated in July 1975. It was originally staffed by a full-time Director and Secretary; since then another full-time employee has been added and student-programmers have been hired on a part-time basis. Funded by the University of Chattanooga Foundation, an HP2000 was installed in October 1975 and was linked to thirty-two terminals located in clusters around the campus. In November 1978 a second academic system, an HP3000, was installed along with additional terminals.

The first two years were spent in consolidating this system and acquiring CAI programs suitable for college level usage. During this time, efforts were made, using newsletters and workshops, to introduce the faculty to the facilities available and to encourage them to undertake authoring projects. This period produced a nucleus of dedicated faculty users who developed programs for their own courses or who tested and used outside CAI materials.

As time progressed, a snow-ball effect became visible with software being added to the system at an ever increasing rate by more and more users. It was inevitable that before long the amount of material on the system would become so large that it would be difficult to manage. This became noticeable as calls were received about programs which had been installed and subsequently 'lost' when the authors (or caretakers) left campus either permanently or on a sabbatical basis. Then, too, as our students gained expertise, programs would appear in unauthorized areas and it was often difficult to determine whether programs in a given account were legitimate or had been put there by student whimsey. Documentation of our CAI packages culminating in a User Guide seemed the only answer.

User Guides

How do you start the documentation process? First we explored how other institutions handled this situation. Many campus academic centers had materials available which were extremely useful. Based on our own observations and that of our users, we finally settled on a format which could be standardized for use with most of our programs. It was decided to list each major CAI system in a manual entitled CAI at UTC. The format used provided space for information regarding the name of the program, its source, an educational description, a technical description and the method for accessing the

program. Within this framework, the guide's purpose was to supply the faculty user with information about the degree of difficulty of the CAI package, how long it took to run and on which system, plus what prior knowledge the student user would require and for which courses the package might be suitable.

The process of producing the guide, CAI at UTC, extended over an eighteen month period. Student programmers proved invaluable in tracking down programs, moving them to centralized accounts, fixing bugs and assisting with the documentation. The first edition of CAI at UTC was published in August 1979; it contained detailed descriptions of over 100 major CAI packages available at UTC. In addition, there were indices of programs by discipline, by level of difficulty and by account. Draft copies of CAI at UTC were distributed to sixteen departmental users for comments, revisions and suggestions. This proved to be a valuable process both for identifying errors and for receiving feedback on programs which had been overlooked.

Although compiling this guide was not easy, we feel it was well worth the effort because we have identified major CAI packages used on campus. Thus, we can provide the new user with information which was previously often inaccessible.

Since many of the packages had instructor and student manuals associated with them, we arranged for the UTC Library to set up CAI Browsing Shelves. This permitted the faculty to check out the materials, while at the same time it relieved us of the task of keeping track of these booklets. Provision was made in CAI at UTC to record the titles and authors of manuals associated with a specific package.

In the process of developing CAI at UTC, we realized the need for documentation of our two computer systems and a remote batch system at UT-Knoxville. As a result we published three other user guides, one for each of the major computer systems. These guides listed the services available (e.g. terminals, short courses, and Newsletters). Sections on computer languages, file structures and program compilation also were included.

Text Editors on our computer systems were used extensively in the process of manual and guide development. These editors provided not only an excellent editing capability but also file storage. Once a guide had been published, the file could be transferred to tape for long term storage; files can be re-installed on the system when yearly revisions become necessary.

Another project which provided valuable documentation involved the collection of data into a summary called an inventory of courses. All departments were contacted and those using computers in course work were asked to return a one page questionnaire for each course involved. The questionnaire ascertained which computer systems were being utilized, how many students were involved and what role the computer played in relation to the course (i.e. required, enhancement or supplementary). The results of the 1978 inventory were compared with those from a similar one in 1976; in the two year period, twenty-four additional courses had introduced the computer into the curriculum (see Table 1). Computer Science, Engineering and Health/Physical Education used the systems for problem solving; the other departments primarily relied on the computers for CAI.

Evaluation of CAI Courses

In the Spring of 1977 the Administration, the English department and the Office of Academic Computing jointly endorsed a proposal to use a major English CAI package for at least one year. Initial planning indicated that this package would be assigned to one third of the freshman class with each of the 600 student participants being allocated from nine to twelve hours of CAI work during the Fall 1977 semester. The fact that the package, which was developed by the Computer Curriculum Corporation of California, contained a very accurate record keeping capability gave the university the chance to evaluate the success of this CAI project. Although it would be time consuming, the decision was made to analyze the computerized records and generate statistical reports.

At the conclusion of the first semester of use, a survey established that, of the students using the CAI, 23% felt that access to these programs had materially altered their grade. However, the records showed that 34% of the students did not attempt to access the material assigned to them (see Table 2). Because statistics were available, it was possible to conclude after the first semester that the project was not as successful in scope as it had been hoped. This permitted the English department to rethink their policy towards the CAI package and determine that in future semesters anyone who did not complete the CAI assigned to them would fail the course. This was a complete reversal from the previous policy of voluntary participation.

Statistics were kept again during the second major semester of usage, namely

Fall 1978. As Table 2 indicates there was a definite difference between semester usage. The numbers of students not participating dropped from 37% to 23% while those who completed their work assignments increased significantly from 6% to 23%.

Starting in the Fall 1979 semester, a special remedial course will be introduced. Using ACT or SAT scores, freshmen showing the greatest deficiencies in English grammar will be assigned to this course which again will make extensive use of CAI. As in previous years, the hours of usage and other statistics will be monitored to evaluate the effectiveness of this new approach.

Developmental Workshops

Once documentation was underway, it was possible to ascertain not only what we had but what we did not have. Therefore, we wanted to encourage the faculty to perceive the needs and induce them to fill the gaps. To assist in the process we continued to offer free short courses to all faculty and staff members. The typical course covered a five week period and consisted of a one hour meeting per week. These short courses discussed topics such as the BASIC language, the CAI system languages and statistical packages (e.g. SPSS).

In the spring of 1979, we undertook a new procedure. At the request of the Nursing Department we instituted an intensive two an half day seminar on Instructional Dialogue Facility (IDF), an HP CAI authoring language. Participants were taught how to use the facility to write and edit their course material. Each person produced a mini-package containing four or five multiple choice questions related to the nursing instructor's area of teaching. This project was well received and successful enough to encourage us to utilize the same format again.

To date four faculty authors have CAI packages being published at the national level in the areas of mathematics, physics and psychology. In addition, a sociology package, written in an authoring language, and funded by a grant is being prepared for distribution. As Table 3 shows, CAI Activity is monitored to determine the major users and follow growth patterns such as the emergence of Economics, Physics and Sociology as new CAI users.

Summary

The work described in the preceeding sections is in a continual state of evolution and development. However, experience has shown us that the usage of CAI is increasing and has a definite educational value. Our academic departments are increasingly finding CAI a worthwhile investment for their time.

Table 1

Inventory of Computer Usage in Courses by Discipline

Department	Number of Courses Utilizing Computing 1976	1978
Biology	0	2
Business Administration	8	8
Chemistry	7	7
Computer Science	10	13
Economics	1	3
Education	2	9
Engineering	16	15
English	0	2
General Science	1	2
Health and Physical Education	1	1
Home Economics	0	2
Mathematics	11	14
Music	4	4
Physics	5	7
Political Science	1	1
Psychology	8	9
Sociology	1	1
Total	76	100

Table 2

Usage of English CAI

	Fall 1977	Fall 1978
Total students assigned	666 (100%)	585 (100%)
Students with zero hours	247 (37.1%)	137 (23.5%)
Students with 0.1 to 1.9 hours	141 (21.2%)	75 (12.8%)
Students with 2.0 to 3.9 hours	130 (19.5%)	83 (14.2%)
Students with 4.0 to 5.9 hours	68 (10.2%)	81 (13.8%)
Students with 6.0 to 7.9 hours	41 (6.2%)	76 (13.0%)
Students with 8.0 or more hours	39 (5.8%)	133 (22.7%)
Mean of Hours of Usage/Student	2.23	4.42

Table 3

CAI Activity on HP2000 System
(Figures for Spring 1978 are not available)

	Fall 1977	Fall 1978	Spring 1979
Chemistry	346 hours	303 hours	137 hours
Economics	-	-	225
Music	116	268	84
Mathematics	141	161	287
Physics	-	-	180
Special Services	94	17	12
Psychology	-	170	59
English	3079	5329	1112*
Education	65	434	254
Sociology	-	24	201
Total	3841	6706	2551

*English usage of CAI is primarily in the Fall Semester.

Elisabeth M. Craig

Abstract

This paper reviews the experiences of developing documentation and other media to support Computer Assisted Instruction (CAI) programs and projects at the University of Tennessee at Chattanooga. The types of documentation discussed include user guides, manuals, evaluations, and short courses. Although the documentation primarily relates to CAI applications, the resources developed are applicable to other areas of academic computing.

Report on Initial Development of Microcomputer

Programs in Reading and Aural Training for Music Students

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In the Music Department at Carnegie-Mellon University, there have been exceptional opportunities to transcend boundaries between the traditional arts and what are usually designated as the sciences and technology. The tradition of combining in one institution the sciences and the arts began with Andrew Carnegie in 1902, when Carnegie Institute of Technology was founded. It became even stronger when Mellon Institute merged with "Carnegie Tech" to form Carnegie-Mellon University.[1]

The Music Department is a conservatory, geared to the training of professional musicians. In this training, solfege constitutes a mandatory two-year course for music students; there is an elective third year. Solfege is the primary music area discussed in this paper.

Solfege, or the Fixed-Do system (a method of sight-singing and ear training), as taught in France and Italy and in the best professional music schools in this country, has pure pitch related structure. This feature provides complete freedom of musical syntax and form. To be put to use, it does not presuppose any harmonic analysis of a piece of music. When reading a new piece of music, the student using solfege will have a tool which is completely flexible and readily usable in music of whatever stylistic period, or whatever tonal ambiguities. Last, and perhaps as important, solfege teaches the student to read in whatever clef in which the music is written. The importance to a professional musician of complete familarity with several clefs was underlined by Arnold Schoenberg (1977) who wrote.

> A musician who is unable to read chamber music or a full orchestral score is one of minor order. And even if he is a specialist, a virtuoso on one or more instruments, he resembles a juggler or a tight-ripe dancer rather than an artist.

It is a difficult task to give the student a truly accomplished sight-reading and pitch perception (which, together, constitute solfege) fluency in two years, and for some it quickly becomes apparent that extra work will be required.

> The learning of even the most basic aural-perceptual skills requires a great deal of drills. In the ear-training course for majors, such time is difficult to find in the classroom because the teacher must spend class time in sight singing and in teaching proper techniques for listening. (Arenson; 1979)

In 1978, the Music Department of Carnegie-Mellon University, in collaboration with David Tuma, of the Electrical Engineering Department, initiated a research project to provide just that kind of help to the students through the use of microcomputers. "The potential impact of microelectric technology on the future of music education is certainly considerable." (Hofstetter, 1979)

MATERIALS

The research was conducted on a Radio Shack TRS 80 microcomputer equipped with a Basic Level II language interpreter. The current system configuration includes a video display on which is produced the music graphics, an alphanumeric keyboard for student input and a microfloppy disk which allows program storage and 32 kilobytes of system RAM. The researchers started the work on a TRS 80 because of its availability and its wide use in institutions across the country. After a time, the researchers perceived the need for more sophisticated graphics resolution and capability and are now transferring their programs to an Apple II.

The electrical engineering and music departments have, to date, with the support of

Report on Initial Development of Microcomputer Programs in Reading and Aural Training for Music Students

Colette Jousse Wilkins

President Richard Cyert, through the internal Carnegie Fund for innovation in teaching, created two programs.

1) A note reading lesson in seven clefs, useful for freshmen, sophomores, and juniors.

2) A lesson in musical dictation through the development of a pitch producing mechanism, or music box.

The note reading lesson provides the students with drills in reading notes on a single staff or without leger lines in any of the seven clefs. The student often enters a university music department with very little reading ability, and learning to read notes with syllables instead of letters can take a lot of practice before it becomes a second nature. The difficulty is reading different clefs is that each one places the same note, or pitch frequency, on a particular line. This means that there is a whole new set of visual and aural perceptions involved with each new clef learned and read. The purpose of the different placement, identified with the clef symbol, is to contain as many notes within the five lines of the staff to avoid the addition of extra lines (leger lines) for very high or low pitches. The students who use this program are the entering freshmen who need to familiarize themselves quickly with reading syllables in treble and bass clefs, sophomores who are learning to read scores of Baroque music such as Bach's Chorales in open score (in which three C clefs are used in addition to bass), and juniors who are learning to transpose and need mezzo-soprano and baritone clefs."

PROCEDURE

The note reading program is initiated by typing the phrase "Run Lesson I." From that point on, the student enters an interactive exercise in which he is provided with all the information he needs to practice the drill. The lesson proceeds in the following manner: a message appears describing the lesson and explaining the available options. When ready to continue, the student, after typing "Enter", is given a list of clefs numbered 1 to 7. He chooses one and a staff is drawn on the screen with the clef symbol he has chosen and ten notes drawn at random. The keys of the top row of the keyboard are overlaid with the names of the notes; the student is provided with a choice of syllables or letter names. As he types his answer, if it is incorrect, the note typed flashes and a message appears, "No, (name of note) is what is flashing now." Then the flashing stops and the original message asking for the name of note comes back. This may be repeated as the student's progress warrants. At the end of the exercise, the student is given an evaluation of his work as well as a grade based on accuracy and tempo. The second lesson is completely different. It provides real time training of the student's pitch recognition. Exercises in pitch perception consist of sequences of unmetered notes played by the computer's sound generator.

In the summer of 1979, two electrical engineering students, under the direction of the author and David Tuma, built a music system, a multi-voiced music box with harmonic content and tone, with software support for dictation drills. The box generates pitches at the same time as notes are generated on the video screen. At this time, although the box has the capability to play four voices, the limitations of the graphic capabilities of the TRS 80 make it possible to generate only melodic dictations (e.g. one note at a time). The electrical engineering collaborators in the project are now transferring the TRS 80 program to the Apple II. This will allow the generation of lessons with solid intervals and chords, composed of several pitches produced simultaneously, as well as the use of a grand staff. Since the program is designed to supplement the teaching received in class, the same principles for developing pure pitch recognition are incorporated. The point of reference is always available; the standard American musical note "A" (440 cycle per second) is used. Neither the key in which the motif is to be played is given nor the starting note, as this procedure follows principles upon which classic ear-training is based.

The musical dictation, or pitch recognition program, is initiated by typing "RUN Lesson2". After instructions and options have been explained, the student starts the dictation by typing: "Enter." A treble staff is drawn on the screen and the reference pitch A=440 is sounded. Then the motif is played. It consists of unmetered pitches forming a melody of five to ten notes. The student types in the syllables for the syllables for the notes he has heard, and they appear on the staff. When he gives the command ENTER, his answer is evaluated. If he has given the correct answer, the notes will disappear from the staff, but if he has missed one or more, these wrong notes will flash and he will be instructed to change them. At this point, he may want to hear the motif played on the music box once more, as well as the reference pitch "A". He may take as long as he needs for solving the problem, but he is never merely given the right answer. This is because the dictations are carefully graded so they will not ever be too difficult for the degree of his cognitive skills, if they are taken in proper sequence.

Currently, the dictations are programmed, but another version, based on random dictation, is under development.

FUTURE PLANS

While the two lessons developed so far have already shown their value in solfege training, the researchers have in mind expanding the microcomputer program sequence to include additional lessons that form part of the standard solfege curriculum. It is planned to keep the existing programs as designed on the TRS 80, in which minor changes and additions can be made to adapt them to elementary education, as there is such a great need for software in music, and more schools are now purchasing the TRS 80.

The research is now continuing on the Apple II because of its much finer resolution, which affords a greater degree of courseware sophistication. Since they have been able to design successful preliminary lessons in sight-reading and in pitch recognition, the researchers are now planning to add the third dimension, rhythm notation, to their list of software.

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FOOTNOTES

The author wishes to acknowledge the significant assistance in this project of David Tuma, Associate Professor of Electrical Engineering, Carnegie-Mellon University. The support of President Richard Cyert and of Dean Akram Midani of the College of Fine Arts was indispensable throughout the project.

[1]At the time, it was Andrew Carnegie's idea "to develop the talent around us." It is obvious from other statements by him that one of Mr. Carnegie's basic objectives was to bring together talent and instruction in both the sciences and the arts.

Clef reading exercise

Fig.1 Simplified flow chart of clef reading program. (S) indicates position of student input

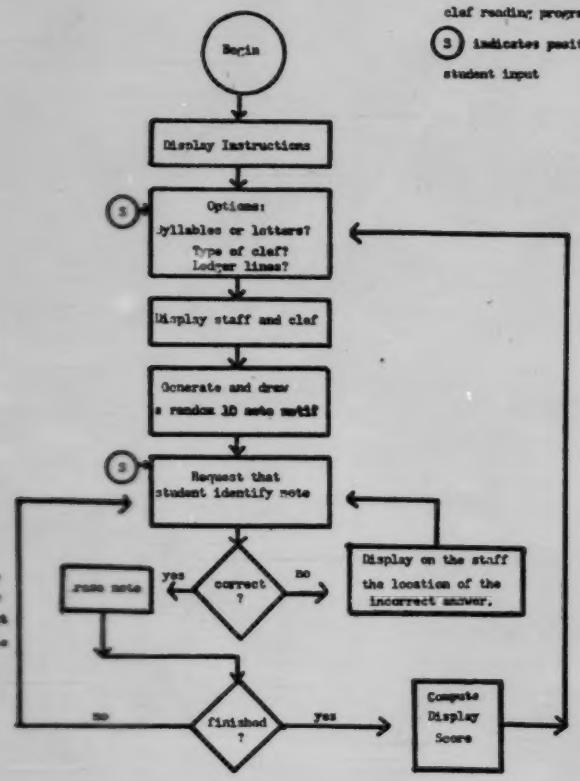
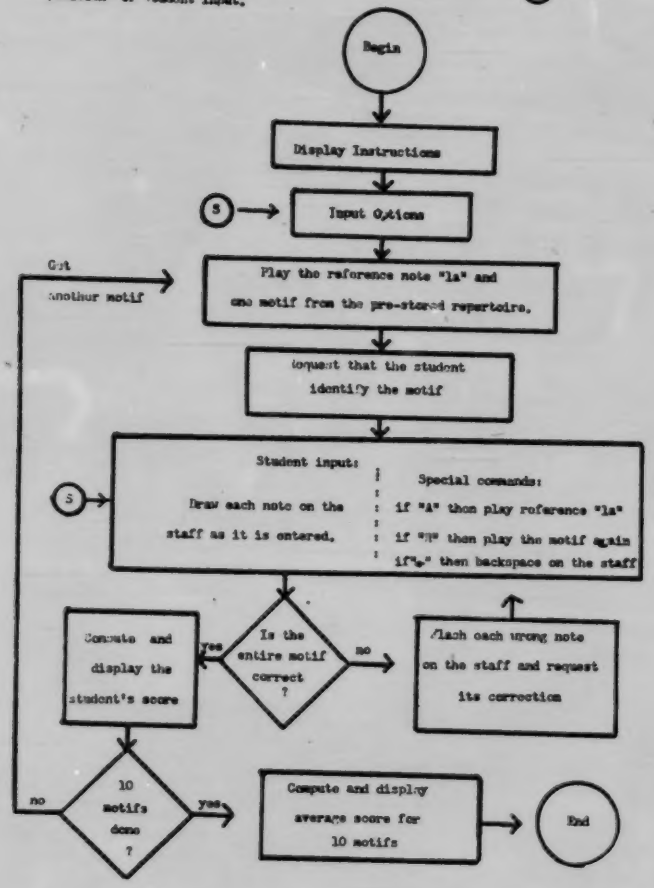


Fig. 2 Simplified flow chart of the melodic dictation exercise. (S) indicates position of student input.



A REVIEW OF CURRENT PSYCHOLOGICAL RESEARCH IN PROBLEM SOLVING WITH IMPLICATIONS FOR COMPUTER-BASED INSTRUCTION

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ABSTRACT

This paper presents a review of current psychological research in problem solving. Following each of the perspectives on problem solving reviewed is a statement of possible instructional implications. Recent publications by J. Greeno, D. Hinsley, R. Mayer, and L. Resnick are reviewed. Simple CAI lessons can be built around the instructional implications of this research: we can teach students how to arrive at meaningful solutions to problems; we can recognize the psychological phenomena of learning sets in developing a blend of instruction in both declarative and procedural knowledge; we can use empirically justified models of problem solving behavior as a guide in instructing students in aspects of that behavior; we can take the effort to be aware of how students transform our teaching routines into their own performance routines and accordingly revise our efforts to teach; and finally, we can dip into the problem solving procedures of experts to discover the structures and methods involved in effective problem solving strategies.

INTRODUCTION

Recent theoretical developments in cognitive psychology have progressed to the point where we can now make initial attempts at applying these developments to instructional settings. In particular, the psychological literature contains potential implications for instruction in problem solving. The literature that we review below should be applicable to any area of instruction in which problem solving is important.

The general absence of effective instruction in problem solving is easy to establish (Rigden & James, 1979, Larkin, 1975, 1977a, 1977b, 1979). Instruction developing the problem solving resilience that examinations typically require (as an assurance of understanding) is not ordinarily a component of instructional activity.

The normally tacit procedural knowledge of any discipline can be discerned by studying the methods used by skilled problem solvers. This information can then be described and organized, instructional materials based on this information can be developed, and explicit instruction in problem solving can result in improvement in the quality and effectiveness of instruction.

The interactive quality of the CAI medium makes the implementation of instructional materials based on psychological task analyses possible. Traditional teaching resources simply cannot create the highly interactive environment effective instruction in problem solving requires.

The implementation of psychological ideas in the development of CAI lessons has been most highly developed in a few sophisticated knowledge-based or intelligent CAI lessons, such as WEST, SOPHIE, WUSOR II, BLOCKS, or BIP (Burton & Brown, 1979; Brown, 1974; Carr, 1976; Brown, 1977; Wescourt, 1977). Such ICAI lessons are beyond the reach of most instructional developers because of the extensive conceptual, monetary, and time resources required to automate psychological ideas.

However, psychological theory can be usefully employed in the development of the more traditional genre of CAI lessons; a compromise can be struck between the most ambitious use and no use of current developments in cognitive psychology. The following review of psychological literature suggests a wealth of instructional techniques short of ICAI that can be brought to bear in developing problem solving materials.

REVIEW AND IMPLICATIONS

Greeno (1976b) has several contributions to make to the understanding of the problem solving process. He has distinguished between "solving a problem" and "understanding a problem". It may be said that one has solved the problem if the correct answer has been obtained. However, to understand a problem, or rather to develop a meaningful solution to a problem, is a different matter.

Greeno has specified three criteria (coherence, correspondence, and connectedness) which a completed problem solution should meet in order for it to be considered meaningful. First, good understanding involves achievement of a coherent representation of the problem, e.g., all of the relevant connections in the problem have been made in the simplest fashion possible. Second, a meaningful solution reflects the important structural properties of the problem in a direct way, e.g., the solution is in a domain of concepts corresponding to the statement of the problem and has not been translated into another domain. Third, a meaningful solution has been related to the long-term memory of the problem solver in as detailed and rich a manner as possible; this should improve the learner's ability to answer interpretive questions about the problem, or solve problems that are presented to him in unfamiliar, novel ways.

Greeno has also characterized the problem solving process as one of pattern completion. "When a problem is understood, the person perceives certain structural relations among components of the problem. However, the structural pattern is not complete, and that is why there is a problem. Thus, problem solving can be seen as a process of modifying a structure in order to complete a pattern." (Greeno, 1976b, p. 141) Successful performance in this pattern completion process depends on having both appropriate knowledge structures and appropriate strategies for generating goals that drive the pattern matching processes needed to obtain an answer.

The implications of the three criteria are: that students should receive training that enables them to solve as much of the problem as possible in some appropriate domain before they resort to translation of the problem into another domain for solution; and, that the elegance and usefulness of particular transformations of certain types of problems should be indicated to students. In short, students should be selective in choosing appropriate representations of the problem statement, and critical of the correspondence between their solution and the problem statement. Students will profit from instruction that draws as much connectedness between the objects of instruction and their prior experience (by analogy or by example) as possible, so that they can rely on this relatedness in developing their solution.

The instructional implication of Greeno's model of problem solving as a process of pattern completion is that instruction should not be segmented into "finding solutions" (recitation) and "understanding principles" (lecture). The understanding of a problem requires that the procedural knowledge used in formulating a solution be closely integrated with the declarative knowledge that gives the problem meaning.

Mayer (1972, 1974, 1975a, 1975b) has studied the differences in learning outcomes as a function of instructional treatment. Two instructional treatments (algorithmic or procedural, and propositional or declarative) were developed and the learning outcomes they produced were detected by variable performance on a variety of posttest question types. His major conclusion is that the effect of instruction is jointly determined by both the subject matter content of the instruction and the cognitive structures (learning sets) activated in the students by the instructional treatment. Here the two different learning sets may be described by the terms "algorithmic" and "propositional"; they refer to the different ways in which students appear to be predisposed to learn.

Mayer has found that the relevant learning set is activated early in an instructional experience. During an instructional treatment, students will selectively attend to aspects in accordance with the learning set activated by this treatment, and will tend to overlook the aspects which would have been activated by the other learning set. Varying instructional approaches will result in qualitative differences in the learning outcomes, not just differences in the degree of learning.

Instructional treatments emphasizing general conceptualization and understanding facilitate solving problems having this same emphasis, while treatments emphasizing algorithmic procedures facilitate skillful solution of familiar problems. There is no evidence of transfer, however, from one kind of treatment to the other.

Because meaningful problem solving involves a skillful blend of procedural and declarative knowledge, the obvious instructional implication of Mayer's findings is to develop instruction that, first, places due emphasis on both kinds of instruction, and, second, helps students transcend the selective oversightedness of the learning sets activated by each kind

of instruction.

Hawkins (1978) has recently developed a concept of "critical barriers" to learning in physics. This may be closely related to the difficulty students would experience if they were receiving instruction of the type not commensurate with their learning set.

Resnick and Glaser (1976b) argue that a major aspect of intelligence is the ability to solve problems. A problem, as defined by Resnick and Glaser (1976b, p. 209), is "a situation in which an individual is called upon to perform a task not previously encountered and for which externally provided instructions do not specify completely the mode of solution."

Since most instruction is incomplete in the sense that the nature of a learner's final "performance routine" is seldom congruent to the "teaching routine" used in instruction, students must "invent" their own performance routines; they transform the experience of instruction into an ability to use their experience.

Problem solving is important instructionally not because certain curricula have strong problem solving components; rather, these curricula have problem solving components because this process is an integral aspect of knowledge, learning, and intelligence.

How can problem solving abilities be enhanced? Piaget has offered detailed evidence that transitions in intellectual competence do indeed occur, but his theory of cognitive development merely describes various stages of intellectual development--he does not offer an explanation of the process by which people move from one stage to another. Similarly, Gagne's "cumulative theory of knowledge" is but a finer-grained state description. Resnick and Glaser (1976b) offer an information-processing model of problem solving as a mechanism to account for transitions in cognitive competence; problem solving has three components--problem detection, feature scanning, and goal analysis.

Based on the experimental evidence cited by Resnick and Glaser, we believe that instructional emphasis on the various aspects of the problem solving model can result in increased problem solving skill. In particular, forcing students to "look ahead" and formulate alternative goals, given a problem statement, enhances their likelihood of selecting an appropriate goal that will lead to a solution. Training in recognition of applicable and inapplicable routines during the problem detection phase can similarly enhance problem solving skills.

In looking towards psychology for help in the practical problems of instruction, we are asking how the subject matter at hand can be translated into psychological descriptions of behavior, i.e., we are engaged in psychological task analysis. Resnick (1976a) has identified four criteria for the applicability of such analyses to instruction. The criteria are: instructional relevance, psycholoogical formulation, instructibility, and recognition of stages of competence. She shows how a current theoretical formalism--the information-processing theory of cognition --more closely meets these four criteria than do the preceding formalisms of behaviorist/associationist, gestalt, or Piagetian psychology.

In outlining the process of psychological task analysis, Resnick suggests how we can go about applying the psychological implications reviewed above to instruction in problem solving: develop a hypothetical rational process model of the subject matter, use it as the basis of a teaching routine, and make an empirical analysis of how student performance routines differ from the teaching routine. These differences are used to revise the hypothesized rational process model. Successive iteration of this process will optimize the competence of the learners.

Larkin (1977a, 1977b) and Larkin and Reif (1979) have applied task analysis in the information-processing paradigm to problem solving in physics. These studies have compared the problem solving processes of more and less experienced problem solvers, elucidating differences in general strategies and in the knowledge structures brought to bear on the tasks. Briefly, experts seem to employ large-scale functional methods, which they can use rapidly and accurately, while novices tend to recall and employ various individual physics principles. Further, probably because they have fewer powerful methods available, novices show a much greater dependence on methods which are general but weak, in particular on means-ends analysis. (In this work "novices" were students who have finished the introductory physics course with high grades--they are thus accomplished problem solvers in their own right, albeit, not experts.)

It is the information which skilled problem solvers can give us about the procedural nature of a subject domain that is of value, not that experts solve problems in special ways per se. Based on her investigation of expert problem solving behavior, Larkin developed a model for effective problem solving. The model stresses that the knowledge base must be organized, and that planning is used to aid in the selection of appropriate knowledge. An initial representation of a problem is constructed, a tentative large-scale functional method is selected, and

it is seen whether or not there is a match between the qualitative features of the initial representation and the method. If there is no match, then the method is discarded: if there is a match, then the procedures of this method are employed in solving the problem.

Larkin (1977a) developed an instructional sequence in the content area of mechanics based on this model of effective problem solving. The results showed that this approach to instruction was better than a control approach based on instruction in cataloging principles and algebraic strategy.

Hinsley, Hays, and Simon (1976) have demonstrated that problems (in this case, algebra problems) are categorized, that the categories contain useful information about how to solve the problems, and that this information is actually used. Subjects were able to correctly categorize problems after seeing only about 20% of the problem text. In the absence of a successful categorization, the information about how to solve that type of problem was not available, and subjects tended to solve the problem line by line. While the problem categories cited by Hinsley may bear close resemblance to "kinds" of problems on a superficial level (distance, rate and time vs. the Pythagorean theorem v. mixture problems, etc.) they reflect deeper distinctions such as those singled out by Larkin when describing the large-scale functional methods employed by experts in solving physics problems.

CONCLUSION

With the above review of recent psychological literature, we have pointed out numerous implications for instruction in problem solving: we can teach students how to arrive at meaningful solutions to problems; we can recognize the psychological phenomena of learning sets in developing a blend of instruction in both declarative and procedural knowledge; we can use empirically justified models of problem solving behavior as a guide in instructing students in aspects of that behavior; we can take the effort to be aware of how students transform our teaching routines into their own performance routines and accordingly revise our efforts to teach; and finally, we can dip into the problem solving procedures of experts to discover the structures and methods involved in effective problem solving strategies.

All of these implications are part of the information-processing models in psychology which are used in developing knowledge-based intelligent CAI programs. However, in order to take advantage of these psychological insights instructionally, it is not necessary to go to the extent of incorporating them in ICAI programs. Each implication suggests an elegant and simple approach to the design of CAI lessons of relatively manageable size.

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THE IMPLEMENTATION OF MICRO-CMI

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ABSTRACT

The past year has seen the development and refinement of a Computer Managed Instruction (CMI) program on a microcomputer. There are several factors which have made this accomplishment possible at this time. First, the Wisconsin Research and Development Center for Individualized instruction development of the CMI program WIS-SIM, and the parallel development of MICA at the University of Wisconsin provided an excellent knowledge base from which to start. Second, the emergence of low cost hardware with significant mass storage capability provided the necessary hardware. Third, utilization of hardware with a mature operating system and development support software utilities enhanced the scope and speed of development. Fourth, the availability of experienced test sites provided helpful; and immediate feedback. The purpose of this paper is to indicate the important characteristics of the system which will assist others in their desire to capitalize on microcomputer hardware for similar applications.

The report briefly describes the antecedent projects, the current development effort, the rationale for use of a microcomputer hardware selection concerns, a system description, and some important design considerations.

PROJECT HISTORY

The MICRO-CMI project has it's roots firmly established in two separate CMI efforts at the University of Wisconsin. The efforts of the Wisconsin R & D Center began in 1972 with an initial program designed to support the management of the Wisconsin Design for Reading Skill Development (WDRSD), and The Development of Mathematical Processes (DMP). Work with the Duluth, Minnesota, and MacFarland, Wisconsin schools revealed the validity of the idea. The initial versions of the system were implemented on a Datacraft Computer located in the Center, and on the Duluth Univac computers. The system became known as the WIS-SIM (Wisconsin Student Information Management) system. The salient findings of early WIS-SIM field tests revealed the utility of the grouping function. This was particularly useful to those schools which employed the concepts of Individually Guided Education (IGE). The grouping provides the teacher with a list of students who are ready to work on specific parts of the curriculum, thus saving hours of work in both record keeping and analysis for grouping purposes.

The field tests resulted in a decision to implement a generalized CMI, one which would support multiple curricula through one program and one implemented on a larger timesharing machine. The University of Wisconsin Univac computer was selected because of its proximity to the project, quality of service, and the broad scope of the timesharing service offered. Field tests with this system revealed that the system was highly valued by the teachers, but that the cost of implementation in a timesharing environment was prohibitive. A test implementation in the Denver Public Schools revealed that the cost to the district would be $13,000 per year per school if implemented on a district basis. Experience in Madison revealed that costs could run between $5,000 and $30,000 per year depending on the number of programs implemented and their level of use.

Management of Instruction with Computer Assistance (MICA) was a concurrent CMI development at the University of

Wisconsin. This project, while remarkably similar in many aspects, has a different thrust from WIS-SIM. In WIS-SIM the grouping aspect of the educational process is emphasized. MICA is a file folder approach to the problem wherein each student is viewed as progressing along lines probably completely independent of others in the class. MICA developed relatively cost effective ways of implementing a comprehensive CMI system designed to support a mathematics curriculum. Version VI of the system was generalized to support additional curricular areas, and the database technologies employed to manage a complex Teacher Corps Project.

It was the combined experience and learning in the above projects which led to the system specification paper for MICRO-CMI, (McIsaac & Baker, 1978). This This document indicates the scope of the MICRO-CMI project, and the order of program development. To date, January 1980, the components of the system reflected by WIS-SIM have been developed and are implemented in sixteen schools in Wisconsin and Illinois. When the project is completed, November 1980, the components of both of the above systems will have been designed, implemented, and documented. The remaining sections of this paper will address a number of issues associated with this development. The most common encountered is, "why implement CMI on a microcomputer?" The nature of our answer to this question is in the next section.

WHY A MICROCOMPUTER

There are four identifiable reasons for implementing CMI on a microcomputer system. They are cost, control, access, and convenience. The early field tests, particularly with WIS-SIM revealed a high cost for program implementation over a timesharing network. CMI programs are not computer intensive, but they require significant connect time. The time required to print reports, and to respond to the dynamic demands of teachers requires a system that is easy to use and available most of the time. The experience in Denver revealed that to implement the system would require a shift to offline sheet scanner procedures. The turnaround time for a given request would be about one week, and teachers would be severely limited in the number of requests that could be made of the system. Cost was indicated to be about $13,000 per school. The experience at MacFarland was even more revealing. MacFarland teachers had grown up on CMI and were quite able to significantly test the system. MacFarland ran three programs in a timesharing environment including math (DMP), reading (WDRSD), and science (SAPA II). The cost to the research project was an equivalent of $23,000 per year in computer time over and above the cost of program development.

Cost was a most compelling factor in the decision to implement a microcomputer version of CMI. The second factor was control. The system, when operational on a timesharing system, imposes down times not related to the operation of the school. In theory it is a small matter since a user has ready access to the timeshared system through the telephone network, but when the whole computing system is in the school, indeed it fits on a single desk, the user is in complete control. When the system fails to operate as specified, there is little doubt that the problem is in the schools' computer. There are no questions about the reliability of a telephone, or the timeshare computer. The problem is right in the schools' computer room. The user knows that, and has the knowledge to turn the machine off and then on again (reboot the system), and often the difficulty will just go away.

When the system is installed on a microcomputer, the user has complete access to the system. The decision to work late, or print report cards all day is not a function of "better rates at night", it is the result of a decision to get the work done now. Also, the user is not faced with the discouragement of high cost long runs. The more one uses a timeshared system, the greater the overall cost. The unit cost is constant. When the system is dedicated to a single application, more processing reduces the unit cost. This is a big incentive to make maximum use of the system rather than minimal use.

A locally owned and operated microcomputer is more convenient. The user does not have to be concerned about logon procedures, printing large batch jobs on a remote computer, coordinating the responsibilities of the telephone company and the computing center and the local staff. There are fewer people involved in a locally based operation and the user finds that to be a much simpler operation.

The small, dedicated, locally based microcomputer seems to be more reliable. Down times will probably be of a longer duration on a locally based micro, but they will be far less frequent. The reaction of the school staffs that have microcomputers in their CMI operation

make far fewer contacts with the R & D Center staff. During the operation on the timesharing system, we could expect at least one call each day regarding the operation of the system from each school. The microcomputer in the school does not generate the level of interaction evident in the past.

The most compelling reason for the microcomputer decision is an economic one. The microcomputer can do the same work as the timeshare network, and can perform at a much lower cost. The speed of transmission is a very significant factor. We are able to present information at a 19,200 baud rate, or nearly 2000 characters per second. At this rate of speed the program is virtually conversational.

SELECTION OF HARDWARE

In order to examine the feasibility of microcomputer technology an Altair computer was acquired in 1977. The Altair is an Intel 8080 based microcomputer and represents one of the most common microcomputer systems on the market. The development of a test scoring program for the Altair revealed the plausibility of developing a system for the emerging microcomputer field (Baker, Peerpong, & McIsaac, 1977). There were some serious limitations in the support software at the time. A high level compiler language was only a promise away, and while the BASIC language had much capability, the interpretive code was judged to be much too slow for the comprehensive application of CMI. The operating systems of the first microcomputers were imbedded in the BASIC language they supported. This severe limitation precluded fast programs operating in a high program overlay environment. Many of these problems have since been reduced, but not all have been eliminated.

The R & D Center employed an LSI-11 based computer as a laboratory control and data collection device. Experience with the DEC RT-11 Operating System in the lab indicated a sophisticated operating system available at a price only slightly above that of the eight bit processor. There are a number of vendors who assemble a Digital Equipment Corporation CPU with their own power supply, I/O boards and other vendor memory. Thus, it is possible to assemble a lower cost computer than that vended by DEC. These same vendors, however, make the DEC operating system available to their buyers. The RT-11 and related processors have the advantage time in field, and most of the program bugs have been eliminated. A review of the sixteen bit computer price performance indicated that they competed favorably with the litany of microcomputers emerging in the marketplace. Moreover, the advantage of software compatability with the entire line of PDP-11 hardware was a compelling factor in the decision. The hardware specifications of the system include the following:

CPU	- LSI-11
MEMORY	- PLESSY 65KB
DISK	- CDC 1.25MB FLOPPY DISK (2)
TERMINAL	- HEATHKIT H19
PRINTER	- CENTRONICS
SCANNER	- SCANTRON (WAS DATUM) Optional

This system was successfully bid for the project by General Robotics Corporation of Harford, Wisconsin. It has performed precisely as expected.

DESIGN CONSIDERATIONS

The current capabilities of the system include a large number of functions. There is space here to only list those which are currently implemented and operational in the test site schools. The specifications include functions which provide:

1. Performance Profile Reports
   The performance profile reports provide information to the teacher, student, or parent regarding the progress of each individual student. The individual pupil progress is reported in accordance with specifically requested topics or between specific dates. The teachers have access to a report which summarizes the progress of all students in the program across all the objectives.

2. Grouping Operations
   The grouping functions of the MICRO-CMI give the user the opportunity to dynamically form and reform groups of students for the purposes of instruction. The commands within this function provide recommendations for grouping patterns, let the user form and dissolve groups, and provide various lists of student groups.

3. Grading
   The grading function is the primary basis for entering student grade information. Grades are entered via the keyboard, and

student grades may be prompted by unit, homeroom, or by group. Grades may be given across curricular areas for a given student, or across students for a given curricular area. The grading structure is defined by the user, and may contain up to 120 different grade identifiers. Each grade may be assigned a value, or weighting for maximum flexibility. During the coming project year, the system will include a scanner for both the automatic grading of tests, for batch entry of student grades, and will provide capability for implementing an individual diagnosis and prescription.

4. Database Maintenance
The database maintenance routines provide for the entry of new students and the deletion of students who have left the school. Also, students must be specifically entered into any of the 37 possible programs supported by the system. (Each separate program will be contained on a separate disk).

5. Listings and Reports
Various lists are possible from the system. They include listing student information, teacher information, and curricular information.

6. Backup Procedures
The system is supplied with prompt backup procedures. After any grading session, or entry of new students it is recommended that the user execute the backup procedures. These will inform the user in a sequence of steps what is required to backup the data and program files.

In order to implement the above specifications on a microcomputer with 2.5MB of mass storage several design considerations were important. The design of the system offers flexibility regarding the shape of the data matrix. It is not a trivial task to shape the arrays so that more students and less objectives can be accomodated, but it was a design consideration. Recompilation is necessary, but the system is basically parameter driven, as so such adjustments are possible. The standard system supports 800 students and records 250 grades for objectives per child. The student record has an automatic packing feature which dictates that some of the lowest level objectives are only retained for the period they are active. The information relative to those objectives is summarized at the higher level, and the student record is packed. Thus, not all information is available at all times, but using such a technique to it's fullest we estimate that one could maintain data on some 2500 objectives per student.

This "packed" record was an important design consideration. In larger mainframe computers the temptation would be to enlarge the file. With a limit to 2.5 MB it is necessary to make careful compromises. The experience of our test schools indicates that the storage of very detailed information over extensive periods of time is unnecessary. Other measures to optimize space available include the careful packing of information into computer words. A date fits into one word if converted to an integer equivalent but requires four words if written in ASCII. Since each student record contains 250 dates, this rather simple observation saves the utilization of 600,000 bytes. When writing systems for microcomputers with limited mass storage, the importance of careful coding of information into small spaces cannot be over emphasized.

Disk access tends to be a little slower on the floppy disk, and it is important to build algorythms which compute addresses rather than search through files. The simple hash coding of ID codes provides virtually instantaneous access to student data. Consequently it is possible to enter the update into the student record at the time it is entered. Intermediate files and batch runs are not necessary, and the user is not required to wait for output.

There are some compromises. The user must recognize the need to partition segments of the curriculum onto separate diskettes. The math, reading, social studies, physical education, and science program will not all fit onto one floppy disk. The school must maintain a separate disk for each of the different programs. Ease of placing into their proper place in the computer, and error checking by the proper disk access indicates little trouble from the forced procedure. However, it is not possible to develop overlap grading between disks without a great deal of work. Objectives in one program cannot be carried in a second. The current users find this to be only a minor problem. In the design of MICRO-CMI we had to give serious thought to the on-line off-line problems of data storage. We have attempted to put those bits of information on a disk that application dictates should be together.

The programs have been designed in a modular fashion. This leads to ease of error correction, but more important,

makes the addition of new capabilities a simple matter. The system is designed to operate in a program overlay environment, in which the root contains all the data access and handling routines. These are callable subroutines, and are always resident in the system. Each of the functional subroutines reside on disk and are called into memory when required. One major advantage of the DEC RT-11 operating system was the support of an overlay linker. The programs supported by the LSI-11 require space approximately five times that available. Since the program is highly segmented, and the system supports the overlay concept, it is possible to run MICRO-CMI with almost no noticeable delay between functions.

The human factor consideration was for a menu driven selection. The user reviews sets of linked menues and chooses the selected function by number. Incorrect responses are simple to trap, and consequently the user sees a safe and forgiving computer. We find that users make significantly less use of documentation because of the menu display and the online explanation and documentation. The high baud rates for display make is possble to present high volumes of information without inconveniencing the user. A page of information takes less than a second.

One RT-11 capability which offers much potential is that of printer spooling. The computer can generate output faster than most microcomputers can print. We have experimented with spooled output wherein the program continues to accept input, and interact with the user, and the output is placed into spooled files which are picked up by the foreground print driving program. There is virtually no degredation of the system when the spooling function is implemented. Our difficulty is keeping the program small enough to fit into memory with the foreground/background monitor.

SUMMARY

The use of the microcomputer for large scale CMI has been demonstrated. The microcomputer, however, is not a $500 TRS-80. It is probably possible to implement this system on one of the smaller microcomputers, but a lot of effort will be required. Also, it is evident that the cost of the hardware to support this system on an Altair, TRS-80, Apple, etc. will be roughly equivalent to the hardware represented by this effort. The hardward components used for the system in McFarland cost the district $12,500. For that price they have 3.75MB of reliable floppy disk mass storage, high speed CRT display, and a 60 CPS printer. The cost of a system with 2.5MB of mass storage can be acquired for less than $10,000. The highly sophisticated small business computers sell for nearly the same amount.

MICRO-CMI demonstrates the viability of microcomputers in the schools. Individualized programs require extensive data collection report generation. MICRO-CMI and programs like it are designed to support that concept, and it is apparent that it can be done in a feasible manner.

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Personal Computing and Verbalizing

or "What Does It Cost to Read a Book?"

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ABSTRACT

A possible future of the personal computer revolution is conjectured using an analogy with books and the reading/writing processes. The addition of personal computing to our own individual toolboxes of skills is compared to the stages traversed in acquiring verbal literacy. Literacy itself is investigated for the stages of illiterate (but aware), literate (able to use the works of others), creative (can express personal works), and dissemination (share personal efforts with others). In the dissemination phase, the large libraries/time-sharing networks and personal libraries/computers are seen to form an interdependent structure for bringing about this cooperative revolution. As part of dissemination, the role of computer-based education lesson evaluation is discussed. Comparing such lessons with books leads to questioning the meaningfulness of such hotly-debated issues as "cost/student contact hour." The widespread availability of inexpensive materials in a broad range of topics, quality, and level make such a statistic a non-question. The user herself becomes involved much more directly in the evaluation process. As a consequence, the revolution then truly becomes a personal one.

INTRODUCTION

Every person possesses an unique toolbox. This box of tangible and intangible helping instruments provides each of us with a store of devices and skills upon which we draw every day. And one of the most exciting events is when we acquire a new addition to our own toolbox. In this paper, two very special tools will be discussed. The older tool of verbal literacy and the new one of computing literacy will be compared for similarities and differences. We will examine the stages of literacy common to each, pointing out the importance of personal books and personal programs. The roles of large public repositories, libraries and timesharing systems, will also be seen to be part of an interdependent structure. And finally, the concept of evaluation will be investigated in the light of personal tools. What is the revelance of asking "What does it cost to read this book or take this program?"

Background

The term "personal computing revolution" has become so commonplace today as to lose virtually all meaning. Yet there are thousands of institutions and millions of individuals who will be touched by this revolution. The question now is certainly not if the revolution will occur, nor how it will occur (widespread use of micro-computers), nor even exactly when (many say by 1985 for 10-20% of U.S. households). Rather, given our propensity to conjecture about the future, the major questions today involve the impact on the individual person, i.e., how will the personal computing revolution affect me?

A similar question has been asked before, although not by so many nor so formally. The earlier question was: "What will it mean for society when the common person can both read and write?" What effect will the addition of this communication tool to the toolbox of a large number of people have on a culture? What future lies ahead when books are widespread and people are not solely dependent on hearing the words read by the elite and learned? Indeed, what will happen when the public can actually write creatively and have their thoughts distributed at large relatively easily? The answers are many and varied, to say the least, as the written word has so permeated the daily lives of billions of people. This massive event of increasing the verbal literacy of cultures is basically a positive milestone in our history, although it is certainly not without its abuses.

I believe all these questions and a multitude of related ones should be investigated in the context of personal computing. Replace "book" by "personal computer"; replace "read" by "take a computer program"; replace "write" by "design and code a computer program". By so doing, we may begin to get a handle on how we can help guide this personal computing revolution.

Literacy

The tools in our personal toolbox comprise much of who we are. The earliest tools acquired included motor. Some of the most difficult to acquire for virtually all of us were the skills required for speech understanding and speech production (Moskowitz, 1978). Those of reading and writing came later. Mathematical reckoning is added to several toolboxes, although Seymour Papert believes it can and should be more widespread (Johnson, 1978). Other skills such as music and superb coordination are also refined for some of us. The intangible ones, such as patience, care, discernment, joy, and awe are invaluable additions.

A process common to most of these tools is that of increasing literacy -- becoming more and more at home with our new acquisitions. The stages of this process are usually considered to be: illiterate, literate, and creative. For definiteness, let us look at Figure 1 comparing computing literacy and verbalizing literacy.

Stages	Mode: Personal Computing (PC)	Mode: Personal Verbalizing
Illiterate (but aware)	Have heard/read about PC Watch people use a PC terminal	Aware of existence of books Listen to people reading
Literate (rely on works of others)	Operate a PC terminal Read messages Play games Take household and educational programs	Learn to read Read letters Read fiction Read non-fiction and reports and textbooks
Creative (express personal traits)	Write messages Learn program design and coding Design and code games Design and code household and educational programs	Write letters Learn to write formally Compose fiction/novels Compose reports and serious books
Dissemination (share personal efforts with others)	Send program copies to friends by mail Publish in magazines Formally submit to publisher for royalties Linkup between person/computer teams	Send written works to friends by mail Publish in magazines Formally submit to publisher for royalties ???

Figure 1. Literacy Stages

It is clear that we have a very long way to go on the literacy scale for personal computing. There are certainly more people in the illiterate stage than in any other (with the probable exception of pre-illiterate). Note, however that such a remark must not be considered to be a derogatory or deprecating one. We tread on dangerous ground if we judge people by the stage they currently occupy. Rather, the major role of the reader and myself should be one of helper -- a "teacher", if you will, based on our own experience with computing.

The literate stage will become more populated as major companies and retailers continue to announce new machines, new features, new game programs, and new application programs. Games will undoubtedly serve as the equivalent to the "hook" of the carnival sideshows used to garner an audience (Modesitt, 1979). However, the more serious applications will provide the major portion of the pre-programmed material. A comparison at this stage with written materials is interesting: how often are we drawn to the newest work of fiction in the bookstore, relative to the newest non-fiction book? Yet how much of our work day involves reading fiction? Careful how you answer!

The creative stage will probably always have a sparse population, except for the very important first substage of writing letters and messages. The true creativeness and importance of such self-expression here must not be over-

looked nor minimized. The sparseness in the other substages is certainly not a reason for despair. We have no cause to flail ourselves (nor our children nor teachers) if only a small percentage of the general population creatively expresses stories and feelings for consumption by the general public. Many of us have taken English composition 101, but how many poems or short stories or textbooks have we written? Yet we have produced many reports and articles which are usually readable and useful. In a similar vein, we should continue in our efforts to provide a powerful and "natural" tool for people to use in expressing procedures and problems to a personal computer. The teaching effort should be widespread, so what better tool than the personal computer itself as a delivery vehicle? In any case, we must not expect an entire culture to be interested in writing professional quality programs.

The dissemination segment of the table is really part of the literacy process for a society, and not so much for an individual. Only those people who actually produce a work (program, book, report, etc.) may be concerned with distributing their efforts. Large distributors and publishers may become involved (Ahl, 1978, Green, 1978). Also likely is a network which involves a person/computer team to communicate directly with another team next door or across the country.

A question in the minds of many people for some time is the issue of what type of network should be utilized. However, in my opinion, the question of a massive time-sharing system or a gaggle of personal computers being used exclusively is not an issue. Don Bitzer and Control Data Corporation have both made excellent arguments for when a large system like PLATO could be useful (Norris, 1978, Statz, 1975). Similarly, small machines have many proponents (Caulkins, 1977, Warren, 1978). It is not, however, an either/or question! Both systems have their roles, with small stand-alone systems operating by themselves perhaps 80-90% of the time and calling on the resources of a larger network 10-20% of the time. Downloading from a large library of programs and/or data on a large system to a smaller one would be fairly common (Modesitt, 1978). The "truth", as usual, lies somewhere in the middle of either extreme, and probably changes over time. The analogy with books is an instructive one. A primary source of the written word is our personal library. Yet there are certainly times when a friend's library or larger library comes in handy, even if only to copy an article for our personal use. This is true even when a bookstore happens to be nearby. Should copying a program from a large computer system onto our local storage device be any harder?

Computer-Based Education and Evaluation

We have mentioned earlier that the teaching effort in the creative stage and probably the literate one also will be substantial. Since it will, in all likelihood, be distributed over a large range of miles and abilities, using the computer itself to help in the instructional process makes eminent sense. The experience gained with large-scale computer-based education (CBE) efforts will be very valuable in the personal computing revolution, as evidenced by a recent Congressional report on "Computers and the Learning Society" (Scheuer, 1978). Hopefully, we will have learned much from the many mistakes made in CBE, as well as the successes.

One of the most intensively studied facets of CBE is lesson evaluation. Let's investigate this aspect further in light of the personal computer revolution and the personal computing/personal verbalizing comparison given in the first part of this paper. "Cost/student contact hour" is perhaps given more attention than almost any other statistic when comparing CBE systems

with each other and with human instructors. Now consider for a moment -- what is the cost/student contact hour to read a book? Have we included the development and overhead costs? Do the delivery costs include the "hardware"? Do they include maintenance? What about cost to the student and/or the employer in terms of lost opportunity? Is the book amortized at 40 hours/week and 52 weeks/year? For how many years? These and many other considerations are hotly debated in CBE discussion. Yet why do we not hear these same "vital" issues argued with respects to books? The widespread availability of a vast spectrum of inexpensive offerings to the general public is, I believe, the answer.

Books are readily available in a wide assortment of topics, quality, and price. A distribution system is in place which permits almost anyone who is so inclined to have their thoughts appear in print. And, the general populace is sufficiently literate to read the resulting efforts and perform their own evaluation, e.g., "Was it good; would I recommend it to a friend?" Another evaluation takes place, to be sure, when a publisher makes a decision about a specific work. However, based on the quality of several recent works displayed in bookstores, one wonders about the basis of that evaluation. Nevertheless, the individual is still given the opportunity to make personal judgements.

It is my firm belief that the personal computer will make a substantial contribution toward rendering questions of CBE lesson evaluation almost meaningless. That is not to say bad lessons will not be produced. Rather, it is to say evaluation (specifically, cost/student contact hour) becomes less meaningful as personal computing continues its phenomenal growth. Personal computers will be used in homes, as well as academic and industrial institutions. The audience is far broader than the one seen in the classrooms, where annual cost/student is such a highly-touted figure. Changing the audience often changes the questions!

In the dissemination stage of the earlier table, we listed several possibilities for sharing our personal efforts: sending copies to friends via mail, publishing in a magazine, formally submitting to a distributor and collecting royalties, and direct linkups. Some of these obviously involve evaluation to be performed by the publisher and distributor. This is very similar to the corresponding efforts required for book publication. However, one of the most exciting aspects is the promise of direct hookups between person/computer teams. In this case, programs, data, messages, etc. can be exchanged without any intermediary, particularly that of an evaluator.

The decreased importance of evaluation by a "non-consumer" in the dissemination process has several ramifications. One is that censorship becomes less viable. Another is that we may be exposed to more "bad" lessons. Also, collecting statistics on student performance is not as likely. Statistics can be useful. However, when applied in a CBE context, there is always an implicit assumption that the student is seriously working on the lesson when data is collected on right, wrong, and unanticipated answers, or answer times, or number of tries, etc. Yet how many times have all of us just "played" with a lesson, perhaps even trying to bomb it or just keying in junk, even for serious material? I certainly am "guilty"! What is the PLATO author/instructor to make of such answers when inspecting her/his datasets? And what is your reaction when a program "catches you" playing with it and slaps your pinkies?

Summary

Personal verbalizing (reading and writing literacy) has had a tremendous impact on our culture. It is my belief that personal computing will also have considerable impact as increasing numbers of people add literate and creative computing skills to their individual toolboxes. Many of these impacts will occur in education, just as they did when personal books became widely available. We will continue to have educational institutions, although their form will probably change. Computers in the home portend significant changes in instructional delivery systems. The wide dispersal of material and the easy networking capabilities will help make "public education" into "interdependent education". Instead of transmitting knowledge solely, teachers will have opportunities to communicate wisdom, motivation, reinforcement, and feelings. We will find ourselves teaching and being taught by people varying widely in locale, age, and ability. Cooperative efforts will be common, rather than the exception as they are today in many educational institutions.

A word or so of caution is in order. As with books, just the presence of personal computers themselves does not guarantee a substantial increase in the literacy of the general public. Rather, society needs to decide that education about this new tool is indeed desirable. Also, there will be concerns about decreased socialization. But have you ever stood around the video game display at Sears and watched one generation, usually the younger, helping another, usually the older? People really do like to assist one another and the personal computing arena is an excellent example. One further note: we must be careful not to rely on a single source, whether for machines or material. This would not be desirable with books, and it no more so with personal computing. Sole source dependency is a poor situation in any area.

It has been over twenty years since this author was first exposed to computers. The excitement with and promise of such tools is longstanding to me personally. With the personal computing revolution, many people have a similar opportunity to experience such feelings. Given the chance to have personal computing become an active and controllable influence in their lives, these individuals can and will, I believe, make invaluable contributions to themselves, their families, their employers, and to society. The role of the written word in many cultures is ubiquitous, and that of the computing process has a similar potential. It is indeed a privilege to be part of this personal computer revolution.

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THE DESIGN OF AN ADAPTIVE CAI PROGRAM FOR THE TEACHING OF WRITING SKILLS

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ABSTRACT

CAI has not been notably more successful than other kinds of instruction in improving student writing. Rather than being adaptive programs, most CAI seems to be encoded versions of programmed texts. This paper describes an adaptive system which generates and updates a profile of the student as he corrects a set of sentences, and uses this profile as the basis for instructional decision-making. This is made possible by the use of two models: a structural model of a correctly punctuated sentence and a problem-solving model for transforming incorrectly punctuated sentences.

That the barbarians are at the gates of literacy has been a continuing theme in higher education for the past decade. But writers of CAI courseware have not been notably more successful than others in manning the barricades against the precipitous drop in student writing skills. There are some good reasons for this. First, we still cannot analyze natural language in ways sophisticated enough to simulate human teaching. This severely limits the scope of problems--essay writing is a prime instance--that can be approached. Second, the nature of the subject matter does not permit a generative CAI in which a relatively small data base produces a large number of exercises. Consequently, even simple embellishments like drill-and-practice are difficult to incorporate because each addition and its attendant expected responses must be written one at a time. Third, there exists no satisfactory model of "writing skills"; and since English teachers seldom agree on what constitutes "good writing", the terminal behavior expected from courseware is not well defined. Finally, there is no model that adequately shows how in fact one does acquire the particular skills of a good writer. Teaching, therefore, tends to be intuitive rather than systematic, sporadically successful rather than especially efficient. Such difficulties are not, of course, the sole domain of one type of courseware. They are acutely felt here, however, since the needs they seek to redress are so great and so evident.

The practical effect of these constraints is that most courseware for writing skills seem to be programmed texts that somehow or other have found their way onto terminals. As such, they really can't justify using the power of a computer. Workbooks, for instance, are far more appropriate if one simply responds to the student's last answer and not the process by which that answer was made. Kearsley (1977) notes in this regard that "most current operational systems have attained little more than personalization or response insensitive instruction". If CAI is to be justified, it must be more than a high speed device for turning pages. There are a number of strategies which take CAI beyond page-turning even given the constraints I've outlined, and I would like to describe some of them now.

The first such strategy is a deliberate narrowing of the intended use of CAI. Most such narrowing now is done by default whenever an author realizes that his optimum objectives can't be met by the technologies at hand. That we cannot simulate human instruction when it comes to essay writing, however, need be a limitation only if we conceive of CAI

as the sole device for teaching. If--as part of a fundamental design decision--we think of CAI as one element within a larger system, we will be more likely to choose tasks for the computer best suited to it and to the filling of gaps elsewhere. Rather than grudgingly defer to human teaching when essays are to be corrected, we should develop courseware that can teach the more mechanical parts of writing--spelling, grammar, syntax, and punctuation. These are areas which can be described in terms of models of correctness derived from the rules and conventions of Standard English. And although these models cannot be manipulated like mathematical ones, their development does enforce the precise articulation of subject matter needed as a first step in engineering adaptive programs.

Similarly, there is a need to develop learning models specific to writing skills, even if such models at first would be rather crude approximations of what is actually involved. John Seely Brown (1979), writing about science education, speaks of the "need for research into the underlying cognitive mechanisms of the 'understanding process'". The need, of course, is no less pressing in teaching writing. A model of the cognitive mechanism might be more readily forthcoming if one saw the student writer sometimes engaged in a kind of problem solving: A sentence may or may not contain mistakes; the problem, then, becomes the discovery of possible errors and the transformation of the sentence into one that is error-free. An approach like this, at the very least, could make use of the literature on problem solving and other artificial intelligence research. It would certainly help to focus courseware around the process by which answers are reached rather than merely the answers themselves.

CPINS is a CAI program that works within the constraints I've spoken of to teach the use of the comma in sentences up to the level of the compound/complex. At present, it is being tested and revised at Vanier College in Montreal. CPINS forms one part of about ten to fifteen hours of CAI instruction--themselves an adjunct to regular classroom work--that deal with dangling modifiers, pronouns, verbs and so forth--the typical freshman composition syllabus. The design of CPINS begins with two models: one is a structural model of a correctly punctuated sentence and the other is a problem solving model for transforming incorrectly punctuated sentences. By "structural", I mean a model that sees the sentence as an arrangement of units (main clauses, introductory elements, and so forth) in which the comma functions as the prime marker and indicator of the logical relationships among these units. In its most complete form (that is, assuming every element happens to be present in a given sentence), the model looks like this:

(I),MC1(sc1),ccMC2(sc2)(S)(NE)

The notation shows the positions of introductory elements (I), main and subordinate clauses (MC1, MC2, sc1, sc2), coordinating conjunctions (cc), series (S), and nonessential elements (NE). Parentheses show an item is optional and arrows indicate permissible shifting to other positions within the sentence. It is further understood that elliptical expressions have been reconstituted to their original structure.

It is best to first look at each component of the model singly (and this, in fact, is the teaching strategy) before thinking of how it comes together with others. The component parts are first taught to the student by way of simpler models. "X, Y, and Z", for example, shows that three equal items in a series are separated by commas including one before the final conjunction; "XXX,YYY" shows that an introductory part of a sentence (XXX) must be separated by a comma from the main part (YYY). And so forth. These simpler models are taught incrementally; that is, after each has been mastered, the student goes on to a problem solving session that includes everything he has learned to that point. The culmination of instruction is using the complete model for compound/complex sentences. The model itself is given to the student, as well as forming the basis of what Gerlach (1975), and others have called a "teaching algorithm" or "functional algorithm of the teaching system".

The second model CPINS uses describes how one's cognitive mechanism can approach sentence punctuation. The model has been derived from observation and interviews with competent writers. IDT (for Inventory-Discrimination-Transformation) is a three-part problem solving process that begins with an inventory (I) which identifies structural units of a sentence using the first model (that is, main clauses, introductory elements, and so forth). A "Discrimination" then compares the way commas are used within and without these units against the models of correctness previously taught ("X, Y, and Z", "XXX,YYY" etcetera). Should the discrimination reveal a discrepancy, then a transformation (T) adds or removes

commas as necessary.

A simple example would be the sentence "I like dogs, cats and rats". An inventory shows that there is a series here ("dogs, cats and rats"); the discrimination, however, shows that the series does not follow the model of correctness previously learned ("X, Y, and Z"): a comma after "cats" is missing. Transformation must follow to add the required comma. More complex sentences ("As a rule I like dogs, cats, and rats, because they are cute.") are handled in the same way, one component at a time. (Here, a comma must be added after the introductory element and removed before the subordinate clause.) Obviously, much depends on the student being able to carry out an inventory of structural units and compare their punctuation to the models of correctness. CPINS tries to ensure success by insisting that the student masters preliminary lessons before trying the problem solving sessions.

The IDT model approximates only one of the ways of correcting sentences with improper commas. It does not satisfactorily account for what Miller (1967) has called the "chunking" process that apparently goes on during the inventory stage. Nor does everyone who corrects a sentence think explicity of a model of correctness. But having recognized these objections, one can say two important things: 1) the IDT model describes a procedure that works; and 2) it permits adaptive remediation based not on the student's answer, but on the process by which that answer was made.

This adaptive remediation is done in the following way. The problem solving sessions give students sentences that typically have three comma errors in them. Should the student correct all three, he gets a brief recapitulation of the principles involved and goes on to the next sentence. One, two, or three mistakes causes the usual CAI branching with remediation and additional tries. Once the student is through here, however, the program asks why he thinks he made the mistakes he did on his first try. (It is, of course, a trivial operation to record where those first mistakes occured.) The student can choose from among four alternatives: he didn't consider it a possible mistake; he considered it, but thought it was right; he thought it was wrong but didn't know how to correct it; and he knew it was wrong but made a mistake in changing it. The first choice coincides with the inventory process, the second with discrimination, and the third and fourth with transformation. Results are stored in a matrix that looks like this:

1	2	3	4	5	6	7	8
1	0	1	0	0	0	0	0
0	1	0	0	0	0	0	0
0	0	0	1	0	0	0	0
0	0	0	0	1	1	0	0
0	0	0	0	0	0	1	1

The top row shows that there were eight errors in this particular set of sentences, and the second row shows that numbers 1 and 3 were answered correctly on the first try. Row three shows an inventory mistake on error 2, and Row 4 shows a discrimination mistake on number 4. Finally, Rows five and six show transformation errors on numbers 5, 6, 7, and 8.

The matrix now allows us a far better profile of the student than if we knew only that his last answer--or indeed any answer--was right or wrong. We can observe, for instance, if a student has made an inventory error, and give him remediation different from that for a transformation error. Moreover, we can distinguish between the help required for a continuing weakness and help required for an occasional lapse. And such distinctions can be made on an ongoing basis. We can decide that a student who has made three consecutive transformation errors needs Remediation A while the student with only one transformation error in his last three tries needs Remediation B. It is essential to see that the definition of the term "last three tries" (or any other parameter we wish to set) changes and is recorded with every interaction between student and system. At present, CPINS has some forty-five different levels of help available depending on the type of error and its frequency. Written as it is in APL/CAT (an authoring language based on APL and developed at the University of Toronto), CPINS is easily programmed to manipulate matrices. For example, by storing results in matrices, one can easily determine past and current performance on a particular topic, weakness in any of the three steps of the IDT model, or overall mastery. These observations can then be used as the basis for instructional decision-making. The result is a program that is at once dynamic and adaptive, and which uses the power of the computer to go beyond the limited help of workbook programmed instruction.

Although CPINS differs in content and procedures, it is similar to the program described by Self (1974) which also uses a profile of the student as the basis for instructional decisions. In

both programs, the profile changes each time the student interacts with the system, which in turn causes a different kind of instruction to be presented. CPINS, however, uses the student's assessment of himself to help create the profile. Only the computer can maintain the sort of complicated record keeping unobtrusively and speedily enough to make the system operationally feasible. This permits a program designer to use the computer for those tasks it is best able to perform, leaving the teacher areas best suited to human intervention--such as skills where models of content or cognitive processes have not been well developed.

CPINS, though operational at the present time, is still in the stages of formative evaluation. As John Seely Brown (1979) has written, such evaluation should be less concerned with proving educational effectiveness than with "thoroughly characterizing the underlying causes of its strengths and weaknesses". By such logic, one would wish to refine and extend the two models central to the program, especially by observing various successful learners at work. It seems reasonable to assume that there are a number of procedures that would work equally well when properly matched with populations. One would also like to explore more fully the device of asking the student why he made the mistake he did; what are the effects of such enforced introspection? What procedures would allow one to infer the causes of error simply from the response made? Answers to these questions may not be dramatic or startling enough to proclaim the day of the computer in education for once and for ever; but without such information, we are less likely to understand and represent the knowledge we need for genuinely adaptive CAI. And the barbarians yet approach.

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CONTROLLING FOR THE COMPUTER VIDEO ENVIRONMENT: A COMPUTER-AUGMENTED VIDEO EDUCATION EXPERIENCE

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ABSTRACT: A microprocessor-based CONTROLLER for the Computer-Augmented Video Education (CAVE) project at the U. S. Naval Academy is described. The CONTROLLER improves the delivery of instruction by removing the video tape player control chore from the student and placing it with the remote computer system that is delivering the instructional material.

The Computer-Augmented Video Education Project (CAVE) began in early 1977. Its purpose was to combine a computer terminal and a video cassette unit into a system that would capitalize on the unique instructional advantages of educational television and computing systems. The interactive powers of the computer were combined with the audio-pictorial capabilities of educational television to form a powerful instructional resource (Pollak, 1978).

The CAVE project has steadily improved over the past two years. The system software, CSIS[1] (Pollak & Schwab, 1978) has developed into a very sophisticated CAI language that is also simple enough to employ that even a neophyte computer user can create instructional material during his first session with the system. Improvements in the system hardware have also occurred. The original CAVE hardware configuration consisted of a DIGILOG terminal, a 12" SONY color TV monitor, a Sony VP-2000 cassette player, and terminal/cassette player switch (Figure 1). A shortcoming of this arrangement was the requirement that the student be part of the overall system control loop. This control chore certainly did not add to and probably detracted from the values afforded by the CAVE system. The present system hardware includes a microprocessor-based CONTROLLER that permits the Naval Academy time-sharing computer (Honeywell 6060 operating under the Dartmouth Time-Sharing System) to completely control the video cassette player, thereby removing the control chore from the student. Commands such as GOTO, PLAY, PAUSE, and STOP are imbedded in CSIS and cause the CONTROLLER to operate the cassette player.

THE CSIS LANGUAGE

CSIS was designed and developed at the U. S. Naval Academy. Its primary goal is to provide computer support for the development of course material for use in all disciplines. Another goal is to provide a system that is easy to author yet sophisticated enough to be used effectively in advanced technical subject areas as well as in the humanities. CSIS has been adapted to accommodate all CAVE (tape play and transport) commands or to be used as a system of computer instruction without video support. An author has the option of two input modes: one is a conversational-mode prompting program, and the other is a preprocessor mode for quick entry. The former prompts the author for all input necessary to build an exercise file. This mode is the best for novice authors to begin using the system. The latter mode, more suitable for advanced users, requires the author to build a source file in a specific format that will be the input file to the preprocessor.

The system provides feedback both for the students and for their instructors. The author can specify the content of each of the following three forms of student feedback: (1) one of several congratulatory messages for a correct response, (2) an appropriate diagnostic message for up to six Predictable Wrong Answers, and (3) an optional message for

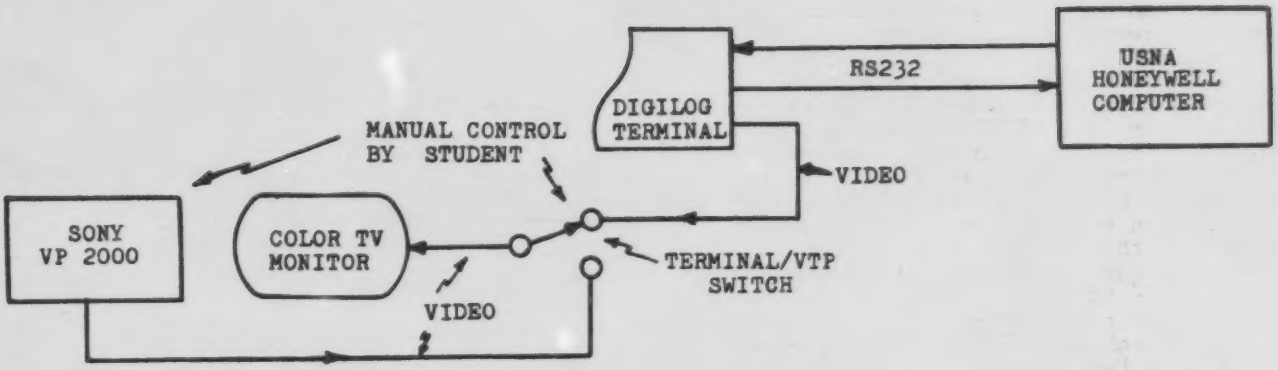

Figure 1 BLOCK DIAGRAM OF THE MANUAL CONTROL CAVE SYSTEM

an Unpredictable Wrong Answer. Further feedback is provided to the students at the completion of each exercise. They are given a user summary that indicates their own performance on the exercise, and an opportunity to comment on anything they wish to about the exercise or the overall system. Instructors receive feedback by analyzing their own set of statistics files from the system. These files contain such things as user summaries, error responses, and the student comments that are recorded at the completion of each exercise.

CSIS offers many features that make it both simple and flexible. One of the main features allows the author to build an exercise in basic building blocks called "frames." A frame may be in the form of a question, a comment, or a help sequence; or it may be a means of turning over control of branching to the student. The frame-type designator determines how the computer is to analyze the student's response, if such response is necessary. Another important feature is that frames may contain numeric and string variables and function expressions -- all under the control of the author. This feature allows the author to present the same "item form"[2] to all students, but each student gets a different set of values for the variables and functions used in the frame. Furthermore, the author can control such things as: the number of tries a student is allowed for answering a question correctly, whether the frame contains graphics, the number of times a frame is to be presented with different variables substituted, allowable correct answers, optional Predictable Wrong Answers and diagnostics, and optional Unpredictable Diagnostic Messages. The system allows the author to designate whether the student receives the exercise in drill or quiz mode. The author can also determine whether the student should be allowed to use special features during a session, such as: calculator mode, selection of specific frames, skipping of frames, halting the exercises, or restarting at the beginning. In addition, the author may choose to turn on or off such options as: lower-case student input capability, random congratulatory messages, and entrapment of student error responses.

THE CONTROLLER

The CONTROLLER, designed and developed at the Naval Academy, allows access to all functions of the SONY VP-2000 cassette player by a remote computer. Coded control commands, transmitted on the same RS232 line that is used for the instructional material, are intercepted by the CONTROLLER which then actuates the SONY controls to carry out the commands. Only a minor modification to the SONY VP-2000 is required for this remote control feature; a reed switch and ceramic magnet are installed in the VP-2000 to allow emulation of the TAPE COUNTER in the CONTROLLER. This modification can be accomplished in a time of twenty to thirty minutes and it does not change the stand-alone operation of the SONY in any manner. All other control/machine-state sense lines needed by the CONTROLLER are already available on the remote connector at the rear of the SONY VP-2000. The block diagram of the CONTROLLER-BASED CAVE system appears as Figure 2.

The CONTROLLER is centered around a 6502, 8-bit microprocessor in conjunction with 256 bytes of RAM and 1024 bytes of EPROM to store and execute the CONTROLLER software. Four wire-wrapped Vector D.I.P. plug-boards and a power supply housed in an 9-1/2"w x 6-1/2"h x 13"d enclosure make up the actual hardware.

The CONTROLLER software consists of about 700 bytes of machine language code stored in EPROM. A simplified flow chart for the software is shown in Figure 3. When the tape cassette is first inserted into the SONY VP-2000, the INITIALIZATION software phase causes the tape to be rewound and then advances the tape to the first incidence of audio; the TAPE COUNTER in the CONTROLLER is reset to zero and the CONTROLLER is then ready to execute commands. Five commands are recognized and they are:

1. STOP - Places the SONY VP-2000 into the stop-mode and causes the TV monitor to display the output of the DIGILOG terminal.
2. GO TO, N - Causes a fast-forward or rewind to TAPE COUNTER number $0 \leq N \leq 9999$ and then places the player in the stop-mode. The TV monitor displays the DIGILOG output.
3. PLAY, N - Causes the tape segment between the current TAPE COUNTER number and N to be displayed on the TV monitor. When complete, the SONY VP-2000 is stopped, and the TV monitor displays the DIGILOG output.
4. PAUSE - Has an effect only if the SONY VP-2000 is displaying a tape segment. If it is, this command causes the VP-2000 to enter the pause-mode and the TV monitor display to return to the DIGILOG output.
5. PPLAY, N - Similar to PLAY, N except that upon completion, the VP-2000 enters the pause mode rather than the stop-mode.

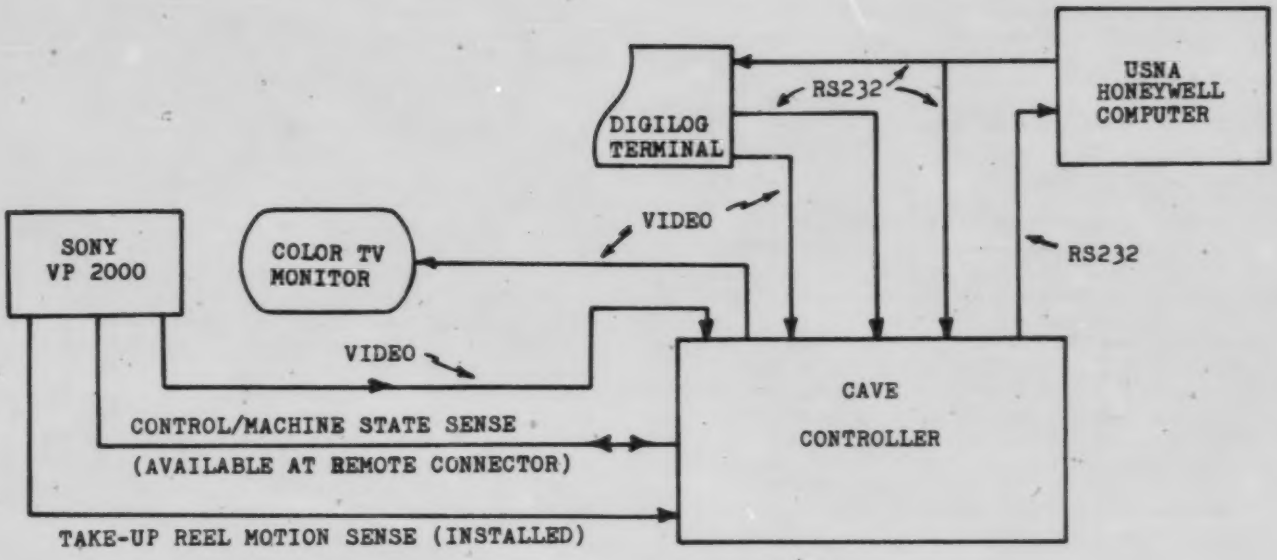

Figure 2 BLOCK DIAGRAM OF THE REMOTE CONTROLLER BASED CAVE SYSTEM

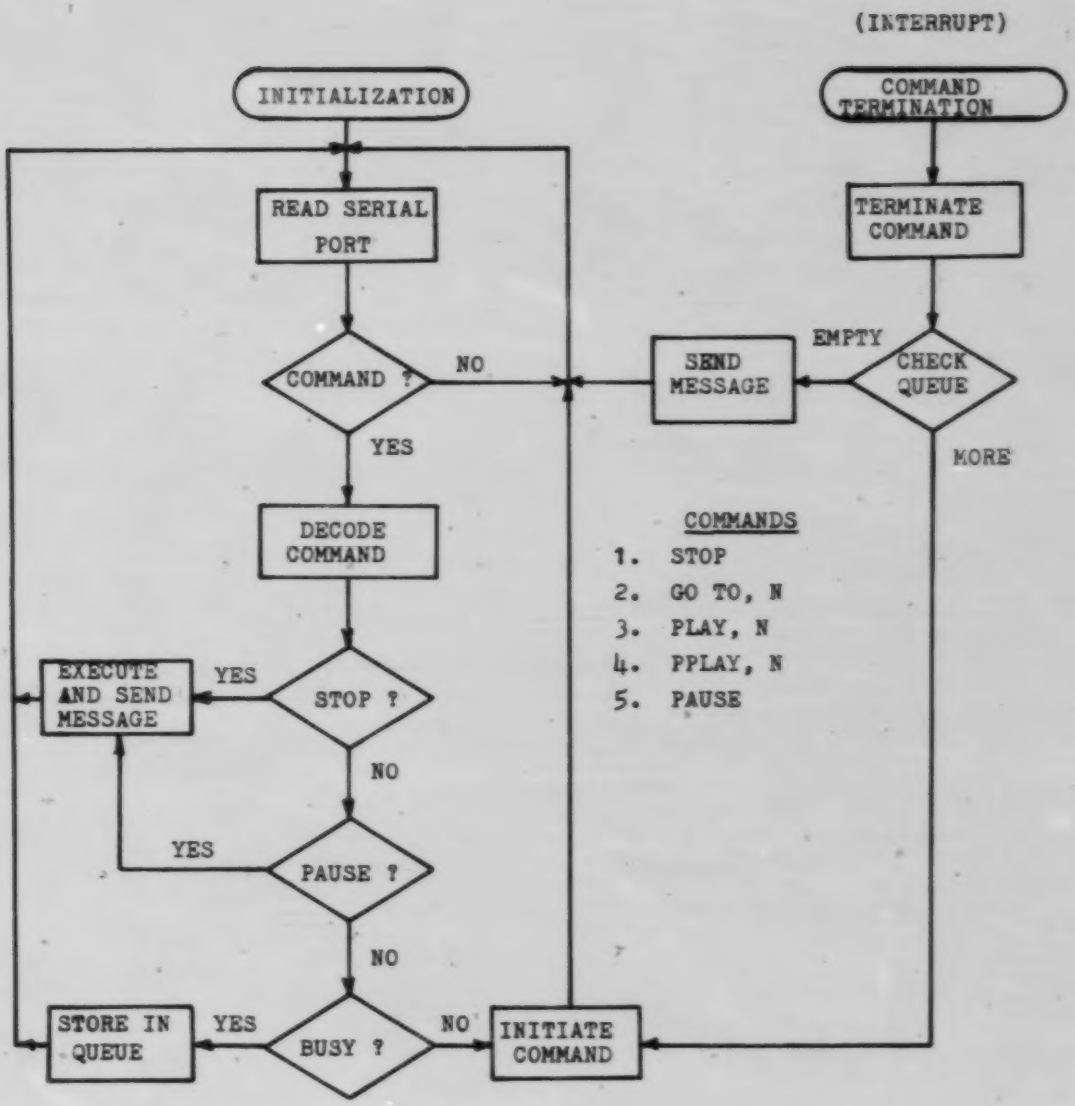

Figure 3 SIMPLIFIED FLOW CHART OF THE CONTROLLER SOFTWARE

As can be seen in the flow chart, STOP and PAUSE are executed immediately while the remaining three commands are considered for immediate execution only if a previously given GO TO, PLAY, or PPLAY is not still undergoing execution. If a previous command is still under execution, the present command will be remembered and execution will be initiated immediately upon completion of the previous command; the CONTROLLER can remember one command, the most recent GO TO, PLAY or PPLAY.

The execution time of GO TO, PLAY, or PPLAY is variable, depending upon the difference between N and the TAPE COUNTER value at command initiation. To insure maximum surveillance of the serial data line from the computer and minimum response time to the command termination condition, an interrupt driven termination procedure was utilized in the design of the CONTROLLER.

CONCLUSION

The ability of the CAVE authoring language to serve the needs of technical as well as non-technical subjects is reflected in the expanding use of the CAVE system at the Naval Academy. There are presently programs in Chemistry, Physics, Economics, and Political Science. Development is also under way in Electrical Engineering and English. Preliminary indications are that the students are responding very favorably toward the supplemental instruction presented by the CAVE system.

The experience that the authors have accumulated with the CAVE concept has strengthened their belief in its value and has shown the way to other system improvements. It has become clear that the video cassette player is the weakest link in the CAVE hardware configuration and we look forward to its eventual replacement by a video-disc technology.

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(1) CSIS stands for Computer Supported Instruction System.

(2) An item form, which defines a class of items characterizing a task, has the following characteristics, (i) it generates items with identical structural characteristics, (ii) it contains one or more variable elements, and (iii) it defines a domain of items.

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AN INTEGRATED DATA MANAGEMENT SYSTEM

FOR COMPUTER-ASSISTED INSTRUCTION

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Introduction

North Texas State University has developed a data management system which handles the collection of student responses, gathering of statistics and scheduling of computer-assisted instruction (CAI) lessons for the School of Music's ear training program. The system was implemented in modular form beginning with the statistics and response gathering functions in January 1978. Student scheduling was added in two parts, one in the fall of 1978 and the other in February 1979. It has proven to be an important part of the NTSU ear training program, greatly increasing the capabilities of the program.

Background

The ear training program at NTSU is the result of the efforts of individuals from the NTSU School of Music and Computer Sciences department. The system is comprised of curriculum, based on the Robert W. Ottman music theory texts (Ottman, 1972), implemented by Rosemary N. Killam of the School of Music; specialized music hardware, designed and constructed by Dan W. Scott of the Computer Sciences faculty; and a lesson entry, editing and presentation system developed by Richard L. Hamilton, also of the Computer Sciences Department.

The CAI system is implemented on a Hewlett-Packard 2000 timeshared computer in the BASIC language. Eight Automatic Music Systems (AMUS) play musical examples for the students and display music notation. AMUS is discussed in Hamilton and Scott, 1978 and the music notation display is described in Hamilton and Killam, 1979. Approximately 400 students use the system as an adjunct to their ear training studies in the first two years of music theory (Bales et al., 1978; Bales and Groom, 1979; and Killam et al., 1979).

In planning for the NTSU ear training facility two major factors provided justification for CAI. First, CAI was the only cost-effective way of providing individualized drill and practice to 800 potential users. Second, CAI provided a convenient and effective method to take advantage of this large group of students as potential subjects for research to improve instructional methods.

With these considerations in mind, the ear training program pursued the following goals: (a) provide a flexible and concise entry language with good editing facilities; (b) collect all responses, again in as concise a manner as possible; (c) keep statistical information in an easily accessible form to allow for weekly reports to the instructors; and (d) provide a means for maximizing student use of the facility. The attainment of the first of these objectives has been discussed in a previous paper (Hamilton and Scott, 1978); the last three are all part of the data management system which is the subject of this paper.

System Overview

The heart of the data management system is the structure of the data. There are four major files: index, statistics, responses and schedule. The index contains an entry for each student, including the student's name, social security number and class. The entry is linked with the student's first statistics record, schedule record and a file where the instructor can leave a message.

The statistics file contains a single entry for each time a student takes a lesson. This entry contains the time the student started the lesson, the time the session was terminated, the total number of questions the student answered, the number answered correctly on the first trial, and the number answered correctly overall. Also included are the lesson name and the number of repetitions of the music which the student requested. The new entry links with the entry for the last lesson taken by the student.

The scheduler uses several files. One contains the schedule itself, the other holds information on the current group of users (ie. those logged on and taking a lesson). The position of each entry for each student is linked with his or her index record integrating the scheduler with the data management system.

The response file is handled separately. In fact, collection of responses can proceed even if the statistics or scheduling features are not used. The response file contains everything the student types into the system once the lesson begins.

Data Collection

Responses

In order to allow a generalized approach to data collection a single scratch file is used to store data while the lesson is in progress. This file: (a) provides a backup in case the computer or the CAI system fails and prematurely ends the session; (b) serves as an interface with the system enabling any program outside of the system to log responses and/or statistics in a uniform manner without risk to the database; and (c) eliminates the necessity of attaching identifying information to each individual response in the response file, so that data are inserted in the response file in blocks. This final point also facilitates retrieval of lesson information at a later time. At the lesson's termination the information in the scratch file is written to the response file.

Statistics

The statistics file entry is also compiled at the conclusion of the lesson from the scratch file. The system then inserts the entry in the statistics file and links it to previous lessons taken by the same student. The system uses these links to restart a student in the proper part of a lesson when he or she has stopped before finishing it and to remind the student of his or her last completed lesson.

Report Generation

Weekly

Each week a summary is printed for each class showing which lessons each student has taken and percent accuracy for each lesson. These summaries are compiled from the statistics file. Some instructors use the weekly reports for grading and others use them to keep track of their classes' progress. They also serve as gross indicators of the effectiveness and popularity of individual lessons.

Semester and Yearly

Because the response files contain large quantities of raw input, a considerable amount of manipulation is required in order to process the data. For that reason the HP CAI system merely records and stores the data on tape. A separate group of programs on NTSU's IBM 360/50 computer processes this data, performing in-depth analysis. A forthcoming paper will discuss these programs and preliminary results from the first year of full system usage.

Scheduling

Significant problems arise from the use of multiple terminals in CAI applications. These include: (a) insuring maximum usage of limited resources (at NTSU this problem manifests itself in the need to provide drill and practice for 400 students on eight terminals); (b) managing the mechanics of scheduling time on the terminals; (c) providing a means of encouraging attendance; and (d) allowing enough flexibility to accomodate frequent changes in the schedule.

On-line scheduling provides the answer to these problems. The first of the problems mentioned above--allocation of limited resources--normally requires some form of scheduling as its solution. The management of the mechanics of scheduling is usually handled by the use of signup sheets or some other manual system. The NTSU on-line scheduler provides this function as an electronic signup sheet. Each student gets the opportunity to inspect his or her schedule and make changes to it during each session.

The schedule itself is kept for only one week in advance. Each student

may sign up for as many half-hour sessions as the system managers allow (this is currently three). At the time a lesson is taken the student has the option of reserving or freeing that lesson slot for the next week and changing any other scheduled session.

Flexibility is built into the system by allowing the student to change his or her schedule at any time. Also the scheduler will allow anyone to log on and use a free slot in the schedule, or a scheduled slot which has not been used, after the first ten minutes of the session. This allows a student to get extra practice in off-peak hours without inconveniencing any other student.

Under heavy usage an additional feature has shown promise. A scheduled slot is only reserved for the first ten minutes of a session. After that, if the time has not been claimed by the scheduled user, anyone can sign on. In addition, that time slot is freed for the next week for some other person to use. This feature encourages on-time attendance during times when the wasting of a session is most harmful; i.e., when there are many users wanting time on the system.

Discussion

The data collection and storage system discussed in this paper has proven effective in the application for which it was designed. The NTSU system collects data in sufficient detail to reconstruct a student session with the exception that it does not currently record the amount of time the student takes to respond. This information will be recorded starting in the Fall of 1979.

Unfortunately, there seems to be a trend in recent work toward neglecting data collection. The older "established" systems (e.g. PLATO) can collect responses and this capability has often been used quite effectively (Lorton and Killam, 1977; Weaver, 1978). Much other research, especially work employing microprocessors, does not face the problem of data collection.

While microprocessors are in many cases a superior--and cost-effective--solution to the delivery of CAI, one of the functions frequently left out of a microprocessor-based system is data collection. This may be acceptable with tested and proven courseware, but how much of the material being presented on microprocessors is tested and proven?

One can run a controlled experiment to gather information on the effectiveness of a lesson, but there is much to be gained from having the ability to process an entire semester's data from a lesson or group of lessons. The authors believe that complete and usable data from student use of CAI material is essential to accurate evaluation of that material.

Conclusions

A data collection and management system has been implemented at NTSU for use in conjunction with the School of Music's ear training CAI program. Integrated with this system is an on-line scheduler. The system collects statistical and response data from eight computer terminals dedicated to music CAI. Also discussed is the advisability of providing facilities for data collection even on systems where that function might seem impractical. It is clear that the effectiveness of CAI needs to be constantly monitored and that with the move toward microprocessor-based systems this monitoring will become more and more difficult without a concerted effort to implement efficient and effective data management systems.

The current state of the art in microcomputers makes it difficult to collect, easily and economically, the large masses of data which are generated when a lesson is heavily used. Two possibilities appear feasible: (a) use a hierarchical system such as described in this paper where statistical data are abstracted from each session (in such a case it might be possible to record completely a certain fraction of lessons selected randomly). (b) use an inexpensive "mass" storage device, such as a cassette tape recorder to store data.

Both of these possibilities will be explored as NTSU evaluates the feasibility of delivering the ear training CAI program on microprocessors.

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THE PEDAGOGICAL USE OF INTERROGATIVE SENTENCES IN LANGUAGE ARTS CAI

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ABSTRACT

Interrogative sentence forms, which are not widely used in language arts textbooks or prose, give CAI developers powerful tools that, one, display grammatical concepts well, two, elicit student responses sharply, and, three, provide procedures for presentation variety. The interrogatives, particularly those involving the auxiliaries BE, DO, and HAVE, can meet several instructional needs--for instance, the explication of verb-subject agreement:

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   1   1 1   1        1    1
 THIS IS A PENCIL, ISN'T IT?
 2    2    2        2       2
THESE ARE PENCILS, AREN'T THEY?
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These examples provide "double takes": that is, the tags ISN'T IT and AREN'T THEY repeat the predicates and present second forms of the subjects--IT for THIS and THEY for THOSE--efficiently in one-line displays. Highly programmable, the interrogatives may be generated by small, concise stand-alone programs intended for microprocessors. It would seem, then, that dynamic CAI techniques being developed for microprocessors stand to suggest pedagogical concepts that can be carried back to static textbooks.

For language arts Computer Assisted Instruction--that is, CAI that addresses questions of grammar and usage--interrogative sentence forms provide the developer powerful tools of instruction. One, a number of grammatical and usage concepts can be concisely displayed in interrogative forms. Two, interrogative practice and test sentences can elicit student responses in a sharply defined manner. And indeed in a broad way interrogative forms give the CAI developer extended opportunities to provide his students significant varieties of instructional materials that may be generated from small, concise, and easily managed data sets in stand-alone programs intended for microprocessors.

What roles do interrogative sentence forms play in conventional language arts textbooks and writing? In the first fifty sets of exercises involving 816 single sentences of one widely used text for the secondary level, 74 interrogative sentences appear, or slightly less than ten percent. Quite clearly this text is attempting to handle written usage, not speaking usage, it must be fairly noted. In speech, on the other hand, questions abound, don't they? But writing is predominantly declarative, isn't it? After all, posing a question in writing is usually a rhetorical process, effective but limited.

An editorial of The New York TIMES of December 10, 1978, commences with "Is the United States in danger of being zapped into submission by Soviet death rays?"--a common enough rhetorical device.1/ After two short exclamatory paragraphs, the third runs amuck with interrogatives, indeed the center of the editorial:

> A question mark, on the other hand, is no mere interrogation; it is nearly always a bill of indictment, a public accusation. Thus, QxP?, when uttered by the chess commentator, really means "by this stage, Capablanca was clearly losing his touch." (Congress dithers on the rebate?) To be sure, the chess critic's rhetoric and syntax can become excessive and complex: QxP!! or even QxP?? and, among ironists, QxP?! (Congress yawns!! and so the

President has canceled the tax rebate??!)

The point is well taken: the question mark itself is not interrogation. What, then, is (are) the interrogative form(s)?

A rather cursory analysis of the 74 interrogatives noted earlier suggests a number of observations to be supported by Table 1. For consistency of presentation, the exercise sentences have been tampered with: one, the sentence forms have been "ellipted"; two, all past forms have been changed to the present, except COULDN'T; three, TO SPEAK is used where possible as a lexical verb, TO HAPPEN being an exception demanded by context; and, four, both the lexical HAVE and the coupla BE have new complements, respectively HAT and HAPPY. That is, Table 1 retains the syntactical forms of the text but attempts to regularize the lexicon.

TABLE 1

Interrogative Forms of a Text with Frequencies

	I		II
	QUESTION WORDS (SUBJECTS) WITHOUT INVERSION		
a	Who speaks 6		
b	What happens 1		
	QUESTION WORDS WITH INVERSION		SUBJECT INVERSION ALONE
		Auxiliaries	
		DO	
c	To whom do you speak 2		Do you speak 15
d	When do you speak 1		Don't you speak 2
e	Why do you speak 1		
f	How do you speak 3		
		HAVE	
g	....		Have you spoken 20
		BE	
h	When are you speaking 1		Are you speaking 3
i	Why are you speaking 1		
		Modals	
		CAN	
j	How can you speak 1		Can you speak 2
		COULD	
k	....		Couldn't you speak 1
		WILL	
l	....		Will you speak 1
		HAVE--lexical	
m	....		Have you a hat 1
		BE--copula	
n	Where are the hats 4		Are you happy 6
o	In what are the hats 1		
p	What are you 1		

With or without inversion, question words like WHO, WHOM, or WHEN of Column I normally elicit lexical replies like TOM and IN THE AFTERNOON. On the other hand, interrogatives formed by inversion alone, as in Column II, normally elicit YES/NO responses. It is to this second column we will later turn our attention--the YES/NO interrogatives. But, before doing so, let's make some observations about Table 1.

Table 1 suggests that the interrogatives are complex. First, given one lexical verb like TO SPEAK, several forms of it appear: SPEAK, SPEAKS, SPEAKING, and SPOKEN. And if we were to switch the present to past, line a would show SPOKE. Second, the auxiliaries play a major role. Third, though almost incidentally demonstrated, it would appear the modals, as represented in lines j-l, follow the path of the auxiliaries. Fourth, from the table we might be lead to believe that the negative NOT does not abound among interrogatives. Fifth, we might note that, commencing with a simple sentence like YOU SPEAK we could generate a number of sentences, if for exercise variety only, by using question forms a-l. And sixth, the BE copula of line n--ARE YOU HAPPY?--seems to present a structurally "simple" question form as do the question words (and simple form verbs) shown in lines a and b, WHO SPEAKS? and WHAT HAPPENS?

But just how simple or how complex are the interrogatives? Let's consider some selected lines:

We can change all the tense forms from present to past, can't we?

I a	Who speaks	...	Who spoke
I b	What happens	...	What happened
II c	Do you speak	...	Did you speak
II g	Have you spoken	...	Had you spoken
I h	When are you speaking	...	When were you speaking

This isn't complex, is it? Now, can we easily change them to negative forms with NOT?

I a	Who spoke	...

How about 'Who spoke not?' Not today.

I a	Who spoke	...	Who did not speak
I b	What happened	...	What did not happen

The auxiliary DO has at least two functions: it assists with some positive questions as in lines c and f of Table 1, and with some negatives, whether they be questions or not, doesn't it?

II c	Did you speak	...	Did you not speak
II g	Had you spoken	...	Had you not spoken
I h	When were you speaking	...	When were you not speaking

How do we contract NOT?

I a	Who did not speak	...	Who didn't speak
I b	What did not happen	...	What didn't happen

NOT is simply contracted in these two instances, isn't it? But now, in the next three NOT is out of position and must move forward to the auxiliary.

II c	Did you not speak	...	Didn't you speak
II g	Had you not spoken	...	Hadn't you spoken
I h	When were you not speaking	...	When weren't you speaking

Enough is enough. We have proceeded through a limited array, exercising predictable rules on tense forms, negatives, and contractions. We may tentatively conclude that with a lexicon of two verbs--SPEAK and HAPPEN--, three auxiliaries--BE, DO, and HAVE--and two question words--WHO and WHAT--that CAI developers should be able to provide a variety of sentence forms in a small lesson. That is, the syntax of the interrogatives is highly programmable.

At this time let's cast off WHO and WHAT and the other question words. Let's

focus on Column II, lines c, g, and h, forming a new table.

TABLE 2

Subject Inversion Alone

c	Does she walk Doesn't she walk
g	Has she walked
h	Is she walking

Table 1 gives Table 2 two forms. Clearly the contracted NOT fits under g--HASN'T SHE WALKED--and under h--ISN'T SHE WALKING--, doesn't it? Thus, our analysis of a portion of a commonly used text suggests, with some extension on our part, two forms followed by three auxiliaries. But this sentence (that you are now reading) poses a problem, doesn't it? It did not open with DOES; but it concluded with DOESN'T IT. Let's quickly do two things: show that, one, Table 2 is very limited, and, two, a simple BASIC program can concisely give us a cheap but powerful CAI device that extends the table. Here is a run of a short program: 2/

```
A - 1 .  AUXILIARY 1 :  PRESENT

  1 .  SHE HAS WALKED.
  2 .  HAS SHE WALKED?
  3 .  SHE HAS WALKED, HAS SHE NOT?
  4 .  SHE HAS NOT WALKED, HAS SHE?
  5 .  HAS SHE NOT WALKED?
  6 .  SHE HAS NOT WALKED.
  7 .  SHE HAS WALKED, HASN'T SHE?
  8 .  SHE HASN'T WALKED, HAS SHE?
  9 .  HASN'T SHE WALKED?
 10 .  SHE HASN'T WALKED.
 11 .  SHE'S WALKED, HASN'T SHE?
 12 .  SHE'S WALKED.
 13 .  SHE'S WALKED, HAS SHE NOT?
 14 .  SHE'S NOT WALKED, HAS SHE?
 15 .  SHE'S NOT WALKED.

A - 2 .  AUXILIARY 1 :  PAST

  1 .  SHE HAD WALKED.
  2 .  HAD SHE WALKED?
  3 .  SHE HAD WALKED, HAD SHE NOT?
  4 .  SHE HAD NOT WALKED, HAD SHE?
  5 .  HAD SHE NOT WALKED?
  6 .  SHE HAD NOT WALKED.
  7 .  SHE HAD WALKED, HADN'T SHE?
  8 .  SHE HADN'T WALKED, HAD SHE?
  9 .  HADN'T SHE WALKED?
 10 .  SHE HADN'T WALKED.
 11 .  SHE'D WALKED, HADN'T SHE?
 12 .  SHE'D WALKED.
 13 .  SHE'D WALKED, HAD SHE NOT?
 14 .  SHE'D NOT WALKED, HAD SHE?
 15 .  SHE'D NOT WALKED.

B - 1 .  AUXILIARY 2 :  PRESENT

  1 .  SHE IS WALKING.
  2 .  IS SHE WALKING?
  3 .  SHE IS WALKING, IS SHE NOT?
  4 .  SHE IS NOT WALKING, IS SHE?
  5 .  IS SHE NOT WALKING?
  6 .  SHE IS NOT WALKING.
  7 .  SHE IS WALKING, ISN'T SHE?
  8 .  SHE ISN'T WALKING, IS SHE?
  9 .  ISN'T SHE WALKING?
 10 .  SHE ISN'T WALKING.
 11 .  SHE'S WALKING, ISN'T SHE?
 12 .  SHE'S WALKING.
 13 .  SHE'S WALKING, IS SHE NOT?
 14 .  SHE'S NOT WALKING, IS SHE?
 15 .  SHE'S NOT WALKING.

B - 2 .  AUXILIARY 2 :  PAST

  1 .  SHE WAS WALKING.
  2 .  WAS SHE WALKING?
  3 .  SHE WAS WALKING, WAS SHE NOT?
  4 .  SHE WAS NOT WALKING, WAS SHE?
  5 .  WAS SHE NOT WALKING?
  6 .  SHE WAS NOT WALKING.
  7 .  SHE WAS WALKING, WASN'T SHE?
  8 .  SHE WASN'T WALKING, WAS SHE?
  9 .  WASN'T SHE WALKING?
 10 .  SHE WASN'T WALKING.
 11 .  -----
 12 .  -----
 13 .  -----
 14 .  -----
 15 .  -----

C - 1 .  AUXILIARY 3 :  PRESENT

  1 .  SHE DOES WALK.
  2 .  DOES SHE WALK?
  3 .  SHE DOES WALK, DOES SHE NOT?
  4 .  SHE DOES NOT WALK, DOES SHE?
  5 .  DOES SHE NOT WALK?
  6 .  SHE DOES NOT WALK.
  7 .  SHE DOES WALK, DOESN'T SHE?
  8 .  SHE DOESN'T WALK, DOES SHE?
  9 .  DOESN'T SHE WALK?
 10 .  SHE DOESN'T WALK.
 11 .  -----
 12 .  -----
 13 .  -----
 14 .  -----
 15 .  -----

C - 2 .  AUXILIARY 3 :  PAST

  1 .  SHE DID WALK.
  2 .  DID SHE WALK?
  3 .  SHE DID WALK, DID SHE NOT?
  4 .  SHE DID NOT WALK, DID SHE?
  5 .  DID SHE NOT WALK?
  6 .  SHE DID NOT WALK.
  7 .  SHE DID WALK, DIDN'T SHE?
  8 .  SHE DIDN'T WALK, DID SHE?
  9 .  DIDN'T SHE WALK?
 10 .  SHE DIDN'T WALK.
 11 .  -----
 12 .  -----
 13 .  -----
 14 .  -----
 15 .  -----
```

Our run has produced both declarative and interrogative forms, in the case of HAVE, 5 and 10 respectively, both past and present. BE's a vagrant, 5 and 10, and 3 and 7. DO is a varmit, 3 and 7, and 3 and 7: DO doesn't contract with the personal pronoun subjects, does it?

For the moment, let's ignore the declaratives. The 2's and 9's are representative of the two interrogative forms of Table 2, derived from our most limited study. SYN indicates that there are an additional eight interrogative forms that we may "play with" in our CAI. What do they suggest? One, here we have some negative forms that are not contracted--3, 4, 5, 13, and 14. Two, we find contracted pronouns and auxiliaries--11, 13, and 14. Three, question tags appear: positive ones--4, 8, and 14; non-contracted negative ones--3 and 13; contracted ones--7 and 11. It is to these tag forms we shall return shortly, but let's tentatively summarize.

First, our array suggests some instructional possibilities for punctuation: two apostrophes, a comma of central concern, and two forms of end punctuation. Second, were we wishing to stress syntax, we have here a potentially strong device to compare and contrast three auxiliaries. And, third, in combination with the declarative forms of SYN, the least that well-conceived CAI can do is to provide, simplistically, sentence syntax variety in grammar (or spelling, or vocabulary, or reading) lessons, if for no other purpose than variety to free the student from boredom. And we might add, parenthetically, exposure to these forms, even without specific purpose, may help reinforce student sentence awareness.

Before turning to interrogative pedagogy, let's peek at what a randomized display of 30 sentences might give us with five pronouns, if only to expose the student to syntactical variety in an elementary school vocabulary drill on verb forms:

```
 7 . THEY HAD WALKED, HADN'T THEY?
 4 . SHE WAS NOT WALKING, WAS SHE?
 7 . WE DID WALK, DIDN'T WE?
15 . THEY'VE NOT WALKED.
10 . YOU DON'T WALK.
 2 . DID WE WALK?
 1 . THEY HAD WALKED.
 3 . SHE DID WALK, DID SHE NOT?
 2 . DO WE WALK?
 3 . THEY WERE WALKING, WERE THEY NOT?
 8 . SHE DOESN'T WALK, DOES SHE?
 4 . WE ARE NOT WALKING, ARE WE?
12 . SHE'S WALKED.
11 . WE'D WALKED, HADN'T WE?
 3 . SHE DOES WALK, DOES SHE NOT?
 7 . WE WERE WALKING, WEREN'T WE?
10 . HE DIDN'T WALK.
 4 . YOU ARE NOT WALKING, ARE YOU?
11 . WE'VE WALKED, HAVEN'T WE?
 2 . WERE WE WALKING?
 8 . YOU WEREN'T WALKING, WERE YOU?
 7 . WE HAVE WALKED, HAVEN'T WE?
10 . SHE WASN'T WALKING.
 4 . YOU HAVE NOT WALKED, HAVE YOU?
 3 . THEY HAVE WALKED, HAVE THEY NOT?
 7 . HE HAS WALKED, HASN'T HE?
 8 . WE WEREN'T WALKING, WERE WE?
10 . THEY DON'T WALK.
 6 . SHE DID NOT WALK.
 4 . YOU ARE NOT WALKING, ARE YOU?
```

Points one and three of the introduction seem to have been supported. Let's turn to the central one: in CAI, interrogative practice and test sentences can elicit student responses in a sharply defined manner.

Here is a list of grammar-usage topics to be used to carry the argument by example:

1. Lexical verb forms (and syntax)
2. Spelling lexical verbs
3. Sentence syntax (interrogatives and punctuation)
4. Countable noun endings
5. Verb-auxiliary relationships (and noun endings)

One, for some students, irregular verb forms like SWAM and SWUM often prove to be stumbling blocks. Here is a portion of an exercise that asks a student to identify the forms of some irregular lexical verbs:

```
NORMA, USE  O  S  D  N  OR  ING  AS ANSWERS.

    >> I HAVE SPOKEN TO MY CLASSMATE, HAVEN'T I? <<

       'HAVE' IS A HELPER IN THIS SENTENCE.

 1 . THE ENDING OF THE VERB 'SPOKEN' IS     ? G
       OOPS.   N

    >> SHE DID FORGET ABOUT HER BUDDY. <<

       'DID' IS A HELPER IN THIS SENTENCE.

 2 . THE ENDING OF THE VERB 'FORGET' IS     ? G
       OOPS.   O

    >> WE ARE CHOOSING OUR PAL, AREN'T WE? <<

       'ARE' IS A HELPER IN THIS SENTENCE.

 3 . THE ENDING OF THE VERB 'CHOOSING' IS   ? G
       OOPS.   ING
```

Additionally, as a reinforcement procedure, whenever an auxiliary appears, it is identified (called a "helper"). Through the use of tag interrogatives, the student often sees the auxiliary twice, once positive, once negative.

A parallel lesson that calls upon the student to spell lexical verbs, regular and irregular contrasted, follows:

```
1 . I HAVE ----- MY FRIEND, HAVEN'T I?
      COMPLETE WITH THE DN FORM OF 'CHOOSE'   ? G
    TRY AGAIN.  ? G
    NO.   CHOSEN

2 . THEY ARE ----- WITH THEIR CLASSMATES, AREN'T THEY?
      COMPLETE WITH THE ING FORM OF 'LAUGH'   ? G
    TRY AGAIN.  ? G
    NO.   LAUGHING

3 . SHE HAS ----- TO HER BUDDY.
      COMPLETE WITH THE DN FORM OF 'SPEAK'    ? G
    TRY AGAIN.  ? G
    NO.   SPOKEN

4 . YOU ----- UP YOUR FRIENDS, DIDN'T YOU?
      COMPLETE WITH THE D FORM OF 'CHEER'     ? G
    TRY AGAIN.  ? G
    NO.   CHEERED

5 . HAD HE ----- ABOUT HIS PAL?
      COMPLETE WITH THE DN FORM OF 'FORGET'   ? G
    TRY AGAIN.  ? G
    NO.   FORGOTTEN
```

Two, while many spelling problems ought to be handled orally (through sound), interrogative forms give the CAI developer some opportunities to work with some spelling matters, in this instance, past and present, singular and plural endings:

```
1 . DOES SHE CHASTISE TOM?
    YES, SHE -----  TOM.                    ? O
      SORRY.  CHASTISES

2 . DID HE CORRECT ANN?
    NO, HE DIDN'T -----  ANN.               ? O
      SORRY.  CORRECT

3 . DID SHE CHIDE SUE?
    YES, SHE -----  SUE.                    ? O
      SORRY.  CHIDED

4 . DO THEY SCOLD JOE?
    YES, THEY -----  JOE.                   ? O
      SORRY.  SCOLD

5 . DID THEY CONSOLE BILL?
    YES, THEY -----  BILL.                  ? O
      SORRY.  CONSOLED
```

The negative response "frame" elicits the O spelling, the positive, the S and D spellings.

Three, interrogative syntax itself is the student's subject matter in the following, with others:

```
'QUESTIONS II' HAS 3 LESSONS.  WHICH ARE YOU
TO DO:  1  2  OR  3  ? 2

WHEN WE SPEAK WE USUALLY CONTRACT 'NOT' IN
QUESTIONS THAT HAVE TAGS, BOB.

  >>  SHE HASN'T SPOKEN TO TIM RECENTLY, HAS SHE?
        READY ?

  >>  SHE IS SPEAKING TO TIM NOW, ISN'T SHE?
        READY ?


BOB, LET'S PRACTICE WITH SOME DECLARATIVE AND
INTERROGATIVE SENTENCES.

        READY ?

A.  HE HAS NOT SPOKEN TO SAM RECENTLY, HAS HE
     1 . WHAT END PUNCTUATION IS NEEDED: 1='.'  2='?'   ? 2
         O.K.
     2 . IS THERE A 'NOT' IN THE SENTENCE: 1=YES  2=NO  ? 1
         O.K.
     3 . DOES THE SENTENCE HAVE A TAG: 1=YES  2=NO      ? 1
         O.K.
     4 . IS THERE A 'NOT' IN THE TAG: 1=YES  2=NO       ? 2
         O.K.

B.  SHE WASN'T SPEAKING TO GAIL YESTERDAY, WAS SHE
     5 . WHAT END PUNCTUATION IS NEEDED: 1='.'  2='?'   ? 1
         OOPS.   2  = ?
     6 . IS THERE A 'NOT' IN THE SENTENCE: 1=YES  2=NO  ? 2
         OOPS.   1  = YES
     7 . DOES THE SENTENCE HAVE A TAG: 1=YES  2=NO      ? 2
         OOPS.   1  = YES
     8 . IS THERE A 'NOT' IN THE TAG: 1=YES  2=NO       ? 1
         OOPS.   2  = NO

C.  THEY DO LISTEN TO ANN TODAY, DON'T THEY
     9 . WHAT END PUNCTUATION IS NEEDED: 1='.'  2='?'   ? 2
         O.K.
    10 . IS THERE A 'NOT' IN THE SENTENCE: 1=YES  2=NO  ? 1
         O.K.
    11 . DOES THE SENTENCE HAVE A TAG: 1=YES  2=NO      ? 1
         O.K.
    12 . IS THERE A 'NOT' IN THE TAG: 1=YES  2=NO       ? 2
         OOPS.   1  = YES
```

Later, in an unshown portion, declarative and non-tag interrogative sentences appear also. Some aspects of punctuation, negatives, and tags are bundled for instruction, as it were.

Four, the O and S endings of countable nouns and simple verb forms often pose agreement problems for students. Below, a section of a lesson uses an interrogative form with DO to reinforce the "count" or number of noun subjects by presenting a singular or plural pronoun in the tag:

```
'O & S MARKERS V' HAS 3 LESSONS. WHICH ARE YOU TO DO: 1  2  3  ? 1

HARRIET, TELL ME THE NAMES OF SOME OF OUR CLASSMATES:

     GIRL  1   ? JANE
        IS--JANE--CORRECT (YES,NO)  ? YES
     GIRL  2   ? LOIS
        IS--LOIS--CORRECT (YES,NO)  ? YES
     BOY   1   ? BOB
        IS--BOB--CORRECT (YES,NO)  ? YES
     BOY   2   ? PETER
        IS--PETER--CORRECT (YES,NO)  ? YES

LET'S PRACTICE CHOOSING SUBSTITUTE PRONOUNS FOR PEOPLE SUBJECTS.

        >> THE GIRL WITH JANE SOMETIMES TALKS. <<

  1 .  ---- SOMETIMES TALKS, DOESN'T ----?   (SHE,HE,THEY)  ? D
       NO.  SHE

       >> JANE OFTEN LAUGHS. <<

  2 .  ---- OFTEN LAUGHS, DOESN'T ----?      (SHE,HE,THEY)  ? D
       NO.  SHE

       >> THE BOYS BESIDE BOB FREQUENTLY GIGGLE. <<

  3 .  ---- FREQUENTLY GIGGLE, DON'T ----?   (SHE,HE,THEY)  ? D
       NO.  THEY

       >> BOB OFTEN WHISPERS. <<

  4 .  ---- OFTEN WHISPERS, DOESN'T ----?    (SHE,HE,THEY)  ? D
       NO.  HE
```

Incidentally, SYN does not reflect this pattern that finds the simple lexical verb form presented in the primary clause, the DO in the tag: HE WALKS, DOESN'T HE? or SHE THINKS, DOES SHE NOT? This interrogative form is a rather powerful tool for language arts CAI.

Five, in a similar lesson, the student makes decisions about both present and past forms of verbs along with decisions about countable noun subjects (that have O and S endings):

```
E. PAST TIME: THE BOYS BEHIND PETER OFTEN WORK--, ---N'T ----?

     13 . WORK-- (O, S, OR D MARKER)          ? G
          NO.  D
     14 . ---N'T  (DO,DOES,DID)               ? G
          OOPS.  DID
     15 . ---- (HE,SHE,THEY)                  ? G
          SORRY.  THEY
   >>> THE BOYS BEHIND PETER OFTEN WORKED, DIDN'T THEY?

F. PRESENT TIME: THE GIRL WITH ROGER SOMETIMES WORK--, ---N'T ----?

     16 . WORK-- (O, S, OR D MARKER)          ? G
          NO.  S
     17 . ---N'T  (DO,DOES,DID)               ? G
          OOPS.  DOES
     18 . ---- (HE,SHE,THEY)                  ? G
          SORRY.  SHE
   >>> THE GIRL WITH ROGER SOMETIMES WORKS, DOESN'T SHE?
```

Here, our same interrogative form allows the CAI developer to juxtapose both simple lexical verbs and the DO auxiliary, using the subject of the tag as a reflection of the subject of the primary clause--again, countable nouns being in focus:

The girl0 with Tom workS, doeS she not?

Or, the same interrogative helps show the plurality of some compound subjects:

Tom and Jane work0, do0 they not?

Or, it may help with "count" or number concepts more broadly:

1 1 1 1 1 1
This is a pencil, isn't it?

2 2 2 2 2
These are pencils, aren't they?

These sample CAI lessons have drawn heavily upon interrogative forms not likely to be found in traditional texts. Some tag forms, in particular, allow "double takes" of subjects and verbs (auxiliaries, that is). Number concepts involving subjects (countable, 0-S nouns; compound proper nouns; and personal pronouns), auxiliary verbs (BE, DO, and HAVE), and lexical verbs (regular and irregular), as a consequence, may be sharply focused.

These examples sustain the premise that, in CAI, interrogative practice and test sentences can help elicit student responses in a sharply defined manner.

Our discussion has inferentially suggested some speculative points for the future. Generative CAI demands that we take a fresh look at the heart of some of our traditional subject matter, particularly as we write for microprocessors. Given a closer look, we may discover that well-accepted practices of the past--some highly prized--may be pitfalls, for both us and the writers of static instructional materials. Indeed, it would seem that new CAI techniques--demanded by efficient programming procedures thrust upon us by small machines, limited storage, and the need for transportability--stand to suggest pedagogical concepts that can be carried back to traditional textbooks successfully. For those of us in CAI development, this suggests, more importantly, that we should emulate only the best of the past that we have severely challenged and that we set new standards for ourselves, unbinding ourselves from static textbooks.

1/ The answer was no, we think.

2/ See Allee and Williams, "A Syntatic Schema and Algorithm for Language Arts CAI," PROCEEDINGS, Association for Computing Machinery, December, 1978, pp. 342-345. The grammatical schema interpreted by SYN is presented, along with suggestions on exclamatory forms.

A MULTI-STATE EXPERIMENT IN COMPUTER-BASED EDUCATION AND COMMUNICATION FOR HEARING-IMPAIRED STUDENTS

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ABSTRACT

This paper describes some recent developments in both computer-based learning and communications programs by deaf students located in diverse locations around the country. It shows that PLATO is an important multi-use resource for permitting cooperative planning, utilization, and evaluation of innovative educational projects for a special needs group.

This project and paper were cooperatively done by persons in Hawaii, Illinois, and Washington, D.C. Descriptions of the setting and programs utilized by members of the deaf communities in each location will be presented.

COMPUTER-BASED EDUCATION with PLATO

The PLATO (Programmed Logic for Automated Teaching Operations) Computer System[1] was developed by the Computer-based Education Research Laboratory at the University of Illinois over the past 18 years. PLATO is marketed by the Control Data Corporation, which has its own systems in Minnesota and Brussels. Independent PLATO systems are located in Illinois, Florida, Delaware, Quebec, and South Africa. More than 500 users can access a single PLATO system simultaneously, each calling up different materials in less than two-tenths of a second. PLATO software includes instructional modes of simulation, drill and practice, calculation, and tutorials as well as utility resources such as sophisticated record-keeping and communications. Instructional materials are available in over 100 curricular areas from early elementary school to university level.[2]

The various sites included in this project have used various instructional and communication modules in varying degrees with hearing-impaired members of the population. Details of these programs will be presented in this paper.

THE COMMUNICATION FEATURES of PLATO

The system supports a variety of communication features. Users may exchange private correspondence, or "electronic mail". A user can compose a message on-line and have it sent instantaneously to another user anywhere on the system. The recipient is notified that a message has arrived, and he may read and respond at his convenience from whatever terminal he is using.

Users are able to have group discussion through the use of note files that permit open participation of any number of individuals. Here users' comments are stored so that they may be read and responded to at any time by any other users who have access to the particular note file. In July 1977 such a forum was created for communication among persons interested in the education of the deaf.

The following is one example of a dialogue in response to the concerned question of a person in Illinois (A) and response of someone in Delaware (B).

Note 5: "OFFEND?"
8/4/77 10:49PM
A: I have a few questions concerning the deaf, and thought someone here might answer them. I am studying sign language, and see very few deaf people. How do the deaf react if some total stranger offers to help them if they look like they are

having trouble communicating in public? Would they be embarrassed or offended? Or would they appreciate it? I have been told that the deaf are often sensitive people, and you should try hard not to offend them. So should I offer my help, or would it be best not to, or would a generalization be grossly inappropriate?

Response 1 to note 5.
8/5/77 7:21PM B:
My sign language teacher out here told me to go up and ask, 'Would you like me to interpret?' She said that the answer is usually 'Yes'.

Response 2 to note 5.
8/6/77 1:45PM A:
Thanks! Next time I run into that situation I'll try that.

Thus one can not only benefit from such dialogue but can also provide useful information to literally hundreds of potential PLATO users across the country.

As more participants joined the discussions, the interest broadened to include handicaps other than deafness. When the ADCIS Special Interest Group for Education of the Deaf recently became the Special Interest Group for Education of the Handicapped, the stated theme of the note file was changed from deaf awareness to education of the handicapped in general. The following shows a discussion sequence from the =sighand=file on the Illinois (cerl) PLATO system.

Note 20
4/28/79 from maggs/law/cerl[3]
You might send a pnote to blind PLATO user smith/mcl and arrange for him to do a term-talk during the Hawaii School for the Deaf and the Blind demo hours. Bob Smith is on the system most days from 9 to 5 Urbana time.

Response to Note 20
5/1/79 from smith/mcl/cerl
Hello Mr. Southworth. Bob Smith here! I'd be glad to talk with you on Wednesday for the demo. I have not tried =talkomatic= but I have tried term-talk a couple of times.

In order to talk most efficiently, you should press NEXT before you start typing again. The talking terminal I am working with says the letters as you send them and when you press NEXT it repeats the whole line. I would be glad to do it.

As far as my background with PLATO is concerned, I knew absolutely nothing about the PLATO system when I started my present job. I have used the talking terminal from the start and I'm very optimistic about its future for anyone who needs this type of medium to be interactive with any computer system.

Because communication and broadening of experience are of special interest in the education of deaf students, it seemed particularly valuable to arrange for these students to carry on discussions with their peers, especially those in distant locations. In this interest, another note file was created specifically for communication among deaf students. During the summer of 1979, students attending summer school at Kendall School and Hawaii School for the Deaf and Blind participated in an initial communication experiment between the two schools. The following are examples of discussion between participants in Hawaii, Washington and a deaf girl in Minnesota.

dnotes / cerl 7/17/79 3:25 pm
southworth / hawaii / cerl
Note 2: QUESTIONS?

This is John Southworth with the HSDB kids visiting the UH Campus. They have some questions:

1. What are your names and addresses?
2. What do you do for fun?
3. Do you go to the beach?
4. Do you like movies? Which ones?
5. When is summer school over? What is it like?
6. Did you go to the White House?
7. Do you like bowling?
8. Do you like roller skating?

dnotes / minnb 7/19/79 7:52 am
hung / kwdc / minnb

my name is hung yee.
(address followed)

yes, I want to roller skate.
no, I not go to beach before.
yes, I want to go to different movies like Moonrakers and other 007 movies
yes, I went to white house many time before.
I want to ride bike.
hung

dnotes / minnb 7/18/79 6:01 pm
leslie / sysgst / minnb

well inm a very specail deaf person.
I can do most thingsO people can do.
I am here to help you kids also.bye

Dear Hawaii and Kendall students,

Leslie is 11 years old. She uses PLATO in the evenings. You can ask her questions, too.
Mr. Mackall
(teacher at Kendall)

dnotes / cerl 7/19/79 2:48 pm
southworth / hawaii / cerl

Hi, Leslie How are you? I am fine. My name is Ronnette. Hi, Leslie My name is Johnelle. I want to be friend. Hi, Leslie My name is Daniellyn. I am 14 year old.

Hi, Leslie My name is Charles. I will go to swim. What is your nationality? Ronnette is Portuguese, Charles is Hawaiian. Daniellyn is Hawaiian and Johnelle is portuguese, hawaiian and chinese.

dnotes / minnb 7/20/79 11:37 am
hung / kwdc / minnb

Hi Leslie, How you feel? I have a nice summer today. Do you have a nice summer today? Where do you live? I will move to Maryland. Do you have brothers and sisters and babies? Do you have a bike? Where do your father and mother work?
Hung

dnotes / cerl 8/6/79 11:07 am
dnotes / gallaudet / cerl forum /
minnb 8/3/79 6:55pm leslie / sysgst /
minnb

I can do sign language,lip reading, and my favorite things are: Tennis, Swimming, Soccer, Cart-Raceing
I got deaf when i was 4 months old and it was a VEERRRYY TERIBBLE deasese.

The PLATO network also makes it possible for an individual to initiate conversation with another person who is using a terminal at the same time. This is somewhat like a phone call, in that one person pages another, and the other must answer (i.e., agree to talk) in order for the conversation to take place. When the call has been answered, the two people are able to converse by typing at the bottom of each other's screens.

Similar conversation among more than two users at a time is possible through files that are created for that purpose. One such file, "Talkomatic", developed by Douglas Brown and David Wooley, has been used extensively for conferencing among educators of the deaf. This mode of communication, similar to a telephone conference call, has proved invaluable in planning events such as the student communication activities discussed above. An example was the conference requested by Laurence Hayes of the Rehabilitation Department of the University of Arizona. He wished to find out about research projects related to hearing disabilities. That =talkomatic= conference involved participants also from the University of Hawaii Department of Speech and Audiology, Kendall School in Washington, Carrie Busey School in Illinois, and the Courage Center in Minnesota. The discussion was summarized in =sighand= so that persons unable to participate could read the results and ask questions or make additional comments.

In addition to this sort of planning conference, an effort was made to bring deaf students together in this conferencing mode. This had an advantage over the group notes communication in that students could get more of a feel for the implications of being so widely separated geographically. For example, questions like "What time is it where you are?" and "What is the weather like there?" could sometimes get unexpected answers. However, for these initial experiences with PLATO communication, the group notes seemed better for most purposes. Each student could compose a note without having to also watch what other students were writing, as is necessary in the conference mode. The group notes method also eliminated the need to coordinate a time when all participants could be on-line at the same time. Notes could be written and stored at any convenient time, and responses could be read later.

PLATO for HEARING IMPAIRED CHILDREN in ILLINOIS

After several years of instructional use in many public school classrooms in Champaign-Urbana, Illinois, PLATO is now an integral part of the educational program for handicapped students in two Champaign schools.[5]

Carrie Busey School is an Individual Guide Education School with 22 classes of students in grades K-5, including three classes of hearing-impaired students, two of educable mentally handicapped, three of

orthopedically handicapped, and one of multiply handicapped.

The three classes of hearing-impaired students are assigned to one large classroom which has been modified to an adaptive environment for sound. The students, whose ages range from six to twelve years, are grouped into two primary classes and one intermediate class. Several of these children are mainstreamed into other classrooms for some of the day. Most of them are reverse mainstreamed with approximately sixty hearing children who come to the hearing-impaired classroom for some of their work.

PLATO has been a part of the teaching resources in the hearing impaired classroom since February 1977. The two terminals in the classroom are used daily by the hearing-impaired children and several children with other handicaps, as well as by some non-handicapped children. Each child receives from one to 2.5 hours of PLATO instruction per week, depending on his or her individual schedule and needs. The children receive math instruction, ranging from simple addition for some students to fractions and functions for others. The mathematics package[4] used here is the intermediate-level mathematics curriculum developed at the Computer-based Education Research Laboratory (CERL) at the University of Illinois. This curriculum includes about 250 PLATO lessons in a structured package that covers a large part of the mathematics normally taught in the elementary grades. Some children also work on phonetics and other topics on PLATO.

Some physical adaptations have been made to facilitate use of the computer by the handicapped children. For example, the hearing-impaired children were found to have difficulty with lessons that required touch input. When the student touches the screen, the computer responds with a "beep". This "beep" assures the student that the touch has been noticed. Since the hearing-impaired students could not hear the "beep", a small red light was installed beside the screen. The light now flashes along with the "beep" when the screen is touched, so there is no longer any confusion about whether the touch has registered.

Attitudes toward PLATO have been very positive for all of the children involved. Children voluntarily stay 30 to 60 minutes after school instead of going home to play. They often work together, helping each other understand the material being presented. The mathematics materials have been found to be so motivating that they are even used as a reward in the school's behavior modification program.

In September 1978, the PLATO program was expanded to also serve the hearing-impaired classroom at Jefferson Middle School, which offers continuation of the hearing-impaired program from Carrie Busey. The middle school students also use PLATO primarily for mathematics instruction. But in both schools the experience has been advantageous in many areas besides learning mathematics. For example, the hearing impaired children are developing a language of direction, not only for following directions, but also for giving directions to the computer. Vocabulary expansion among the hearing-impaired children has been marked.

In all, the experiences of the children and teachers have been positive and rewarding. PLATO has proved a very useful tool for individual instruction for both the hearing-impaired students and their classmates.

PLATO FOR HEARING-IMPAIRED CHILDREN IN WAHSINGTON, D.C.

Kendall Demonstration Elementary School (KDES) is a federally funded school charged by P.L.91-587 to:

1. Provide quality education for hearing-impaired children of the metropolitan Washington, D.C. area from the onset of deafness to age 15; and
2. Develop, test, and evaluate educational materials, methods and programs for use in other schools for the hearing-impaired.

Kendall is divided into four departments: Pre-School (ages 0 to 5); Primary (ages 5 to 9); Elementary (ages 9 to 12); and Middle School (ages 12 to 15). Each department is under the direction of a supervising teacher. Average class size is four or five students. Instructional approaches vary from self-contained classroom formates to teaming; from text book orientation to multi-media.

In March of 1979 KDES and Control Data Education Company began a collaborative research project to explore the application of PLATO to a hearing-impaired elementary student population. Two terminals were used: one in the building housing the Pre-School and Primary Departments and one in the Elementary/Middle School Buildings. The focus of the project was the field testing of CDC's Basic Skills Math lessons and the Colorado Hearing and Speech Visual Memory Lessons within the elementary and primary instructional levels. Additional

activities focused on exploration of alternative lessons strategies and on PLATO's communication capabilities for classroom instruction.

The Basic Math Skills are part of a Basic Skills Learning System that was originally developed to provide an alternate method of learning for 16 to 24 year-old, functionally illiterate adults. The package utilizes both the CMI and CAI functions of PLATO. Students are diagnosed by an inventory test and then placed in an appropriate lesson. Pre-tests, tutorial lessons, drill and practice sessions, reviews and post-tests follow. Records of the student's activities are kept by PLATO and can be used by teachers to evaluate progress. Content ranges from grades 1-8.

During the last four months of the 78-79 school year, some of Kendall's Elementary and Middle School students were exposed to this material. Each student had approximately 2 half-hour sessions per week. These sessions were monitored by the project director in order to gather information on the student's ability to interact with the lesson material.

The Colorado Hearing and Speech Phase I materials were designed for use with learning disabled children (K-3), were audio based, and dealt with Visual Memory Skills. Phase II of these materials were designed without the audio unit, utilized PLATO's touch feature for input, and included the areas of Visual Memory, Visual Discrimination, Word Detail, and Letter Names.

During the four week summer program at Kendall (1979), some of the primary-aged students utilized the Phase II materials. The students were at the terminal twice a week for approximately 10-15 minutes at a time and were monitored by their teachers who were able to choose the lessons and exercises for each individual child.

The exploration of coursewhere alternatives and of PLATO's communication possibilities opened up a link for three programs for hearing-impaired students. The activities resulting from this link were discussed in detail in an earlier section of this paper.

Other uses of PLATO at Kendall included the following:

1. Games sessions before school--Two students per day were permitted to sign up for a fifteen minute period of math and language games before classes started. This was a highly competitive time, but also a time when cooperation had to be used to achieve a common goal.
2. Sentence construction sessions--One teacher used a lesson on "Making a sentence" with a group of low functioning students. The use of the touch screen and the subsequent acting out of a correctly formed sentence created a new element of excitement in written language experience for these students.
3. Typing lessons--One student was interested in learning to type. As a reinforcement for his work on math lessons, he was permitted to take an on-line course. This school year three students took the course in preparation for the communication project among the deaf schools using PLATO. They had 10 minutes five days a week to work on it.
4. Reinforcement of classroom lessons --Several elementary teachers have been using PLATO to reinforce work in the areas of basic facts, subtraction with regrouping, multiplication by a one-digit number and basic fractions.

PLATO has been a motivator for Kendall's students. It has provided opportunities for independent learning, for cooperating with other students to achieve common goals, for communicating with hearing-impaired students in other cities, and for developing thinking skills. Kendall's teachers have found PLATO to be a new method of presenting materials in a way that not only excites the students, but also provides feedback for the children while freeing the teacher to work with smaller numbers of students.

During the present school year, Kendall is committed to a continuation of the research designed to explore the potential application of this technology to hearing-impaired students. Contact with the Illinois and Hawaii groups continues to supplement the efforts at the site in Washington, D.C.

Based on the experience last year and research presently being carried out in the area of instructional design on the Gallaudet campus, the major focus of the present research is the generation of a set of basic guidelines to be applied to both the revision of present and the development of new courseware offerings for hearing-impaired students. Evaluation and validation of these guidelines will be central to this effort. It is projected that the application of such guidelines in the future will permit a broader utilization of computer based technology for the hearing-impaired.

TECHNOLOGY AND THE DEAF IN HAWAII

The Deaf Action Group of Hawaii[6] has been a leader in encouraging development of improved communication services for the hearing-impaired. They have organized a network of teletypes in the Hawaii School for the Deaf and the Blind, hospitals, local offices of the Department of Vocational Rehabilitation on each island, and even a savings and loan institution in Honolulu. These allow for teletype-teletype communication via ordinary telephone line with acoustic coupler equipment.

The Educational Use of Computers Unit[7] at the University of Hawaii Manoa Campus has worked to assist both campus and community groups dealing with the hear hearing-impaired. During the summer of 1977 they supported a sign language class in terms of videotape, slides and computer resources. Sign language lessons were videotaped to accompany the Ameslan class. A pilot project was started to develop slide/tapemodules on basic finger spelling. These have been used with the APL IBM 370/158 on the University of Hawaii's IBM 370/158 computer. A similar drill and practice series was planned for use on PLATO with the microfiche slide capability of the PLATO plasma terminals.

Thanks to a grant, Edu-Comp was able to hire a deaf student attending the National Technical Institute for the Deaf in Rochester, New York, who was home in Hawaii for the summer.

About this time, the University of Hawaii started a CBE Pilot Project to evaluate various CBE alternatives. Included were eight terminals linked to the University of Illinois PLATO system. As a means of improving communication between persons in Hawaii and on the mainland who were interested in the hearing-impaired, a "group notes" file, described earlier, called =deafaware= was created. This file was open to reading or writing by anyone having access to the Illinois PLATO system.

CONCLUDING REMARKS

This initial experience with deaf student communication through group notes and on-line conferencing has provided a unique opportunity for sharing among students and teachers of geographically distant schools with similar populations. We look forward in this academic year to discovering new methods of utilizing PLATO in the education of hearing-impaired students and anticipate that this will continue to be a rich and rewarding experience for all.

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2. Lyman, Elisabeth R., PLATO Curricular Materials Number 7, February 1979, CERL Publications, University of Illinois, Urbana, Illinois; Control Data Education Compnay, PLATO Courses, Minneapolis, Minn.: Control Data Corporation, Fall 1978.
3. Entries are headed with the date of the entry and the PLATO "address" (identification) of the participant. PLATO addresses for the authors of this paper are southworth/hawaii/cerl, dugdale/matha/cerl, phil mackall/gallaudt/minnb, and jan richardson/gallaudt/minn.
4. Dugdale and Kibbey, Elementary Mathematics with PLATO, second edition, July 1977, CERL Publications, University of Illinois, Urbana, Illinois. Support for this curriculum development was provided by the National Science Foundation (US NSF C-723) and by the State of Illinois.
5. Dugdale and Vogel, "PLATO Instruction for the Hearing-Impaired," Proceedings of the Second International Learning Technology Congress and Exposition of the Society for Applied Learning Technology, Orlando, Florida (February 1978); Dugdale and Vogel, "Computer-based Instruction for Hearing-Impaired Children in the Classroom", American Annals of the Deaf, October, 1978, pp. 730-743.
6. For infomration on the Hawaii Deaf Action Group, write: DAG, c/o Information and Referral Center for the Hearing-Impaired, 1150 S. King St., Honolulu, HI, 96822.
7. For information on the Educational Use of Computers Unit, write: Edu-Comp, Sinclair Library Room 2, University of Hawaii, Honolulu, HI, 96822. Author's PLATO address is: southworth/hawaii/cerl.

INDUCTIVE INVESTIGATION USING THE APPLE II

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ABSTRACT

The microcomputer is a new tool in the classroom of elementary and secondary students in Minnesota. This powerful tool is becoming increasingly essential as the learner is the focus of the curriculum. With the microcomputer the student discovers relations and tests ideas in a new environment, one called the real world. Programs will be demonstrated to investigate concepts in mathematics. The process can be extended to science.

Leading students to "discover" properties about curves or the graphs of linear equations has not been the easiest of tasks for many mathematics teachers. Appreciating the subtleties of mathematical theory while guiding students through the abstractions has defeated a few teachers to the point of dropping inductive reasoning from algebra and geometry courses.

Having proper tools is a key to developing exercises in inductive thinking. The computer may be the motivational device with the scope, speed, and capability to re-introduce induction into the math curriculum. Microcomputers are relatively low cost and sufficiently popular and available that teachers can plan to use these tools throughout their courses.

In Minnesota the microcomputer most widely used is the APPLE II and so the examples chosen here are from that system. The computer programs are ones developed by staff of the Minnesota Educational Computing Consortium (MECC) and implemented as part of the curriculum in classrooms in Minnesota. The programs described hereafter deal with linear equations and conic sections.

LINEAR EQUATIONS

Graphing linear equations of the form Y=MX+B or of the form X=B is usually a tedious (but not trivial or unproductive) exercise in plotting a series of points (X,Y). Once the student has calculated the value for each Y as it corresponds to an X and physically plotted these points for a few specific equations, the technique and relational concept has been taught. Learning and understanding must yet take place. Frequently, how quickly the student is able to "see" that graphs of the form Y=MX+B or X=B are straight lines is a function of arithmetic and artistic skills.

Instead of graph paper, pencils, colored pens and a straightedge as the tools for this study, the student is seated before a computer system. As Figure 1 illustrates, the system consists of an APPLE II microcomputer (labelled "A" in the figure) with a black and white monitor or

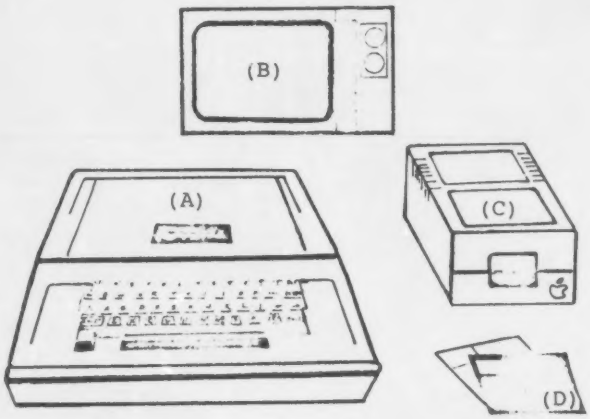

FIGURE 1

colored TV (B) to display what is input or the information returned by the computer. The disk reader (C) makes it possible to store and retrieve information quickly from a floppy diskette (D).

The student runs the program SLOPE, which states that "this program will graph up to 5 linear equations on one axis". Next the program instructs the student to "type in the equations in the form: Y=MX+B or X=B" with the following examples supplied for format:

Y=2X+4 Y=5 X=3 Y=2/3X+6 Y=-1/2X+4

When the RETURN key on the keyboard is pressed, the computer displays the X- and Y axes with units marked off on each. The student is then prompted to type in the first equation. After typing the equation and pressing the RETURN key, the student sees displayed a series of points that satisfy the equation given. The student can personally verify any point on the graph. The display will remain on the screen indefinitely for the student to examine. It will stay there for further graphings if the student answers YES when the computer asks "Do you want another equation?"

If the first equation typed is Y=X and the second equation is Y=-X, the display would look like Figure 2. As many schools are using color TV sets with their

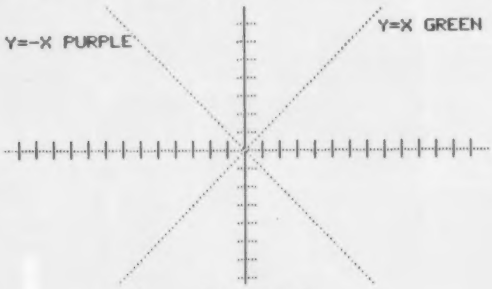

FIGURE 2

APPLE II microcomputers and as color is a special enhancement of the programming capability of the APPLE II, the program SLOPE identifies and uses color to distinguish the graph of each linear equation. For the display given here the computer states below the graphs that "Y=X GREEN and Y=-X PURPLE". (Since this page is not printed in multiple colors, the identification in the display has been moved to be near each line.)

The teacher may guide the investigations of the students by suggesting the sequence of equations that students will graph via the computer. The first equations have graphs that pass through the origin (0,0) and vary in slope. Discovering the relation between the coefficient of X in the equation of the form Y=MX+B and the slope of the line is one of the objectives. The second objective is to determine the meaning of "a negative slope".

After the student has examined many graphs of the form Y=MX, a sequence of graphs in the complete form Y=MX+B (where B is not zero) can be graphed to analyze the significance of "B" on the graph of the equation. Later, families of equations can be grouped and graphed together to pictorially experience the relations that exist between equations having the same "M" and between those having the same "B".

Some schools have closed circuit TV sets or videotape units that can be connected to the microcomputer to allow an entire classroom of students to view the display and to investigate graphs as a group. Large or small group investigation on a topic like the graphing of linear equations using the program SLOPE permits students to express their theories and to test their ideas with those of other students.

When the computer does the graphing, the learning will not be less exciting or permanent. In reality, when using the computer in this investigation the students attention focuses on the general principles involved in the study as opposed to losing a "fix" through the arithmetic computation and the "side-tracking" of calculations, checking and plotting.

The following series of equations offer an example of how the slope concept can be explored with a class. The first equation graphed is Y=X. The position of this line is discussed before another line is graphed on the same set of axes. Then the equation Y=2X is graphed. The meaning of slope is examined with reference to each line. The class verifies the continual slope idea by selecting points on the line and tracing the "rise" versus the "run". These two lines are then left on the screen as a third line is graphed, for example: Y=1/2X (see Figure 3). The contrasts between Y=2X and Y=1/2X are now examined. The fact that Y=2X is steeper than Y=1/2X is one of the first generalities. Y=X is

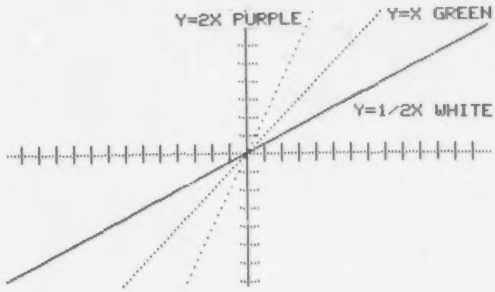

FIGURE 3

considered the normal to which all other graphs are compared and viewed. All three graphs pass through the origin.

Before answering NO when the computer asks "Do you want another equation?" and YES when it asks "Would you like to run this program again?", a new set of axes is drawn. Another series of equations can be graphed, examined, and discussed, for example, Y=-X, Y=-3X, and Y=-1/3X. The vertical axis can be the frame of reference and the position of a line can be described relative to the Y-axis. Conjectures can be stated and students can begin to picture where a line will be drawn before it appears on the screen.

After a set of equations has been graphed and studied, the screen is cleared in seconds. Consider the following equations: Y=X, Y=X-4 and Y=X+3. For the first time all the lines do not pass through the origin and the "intercept" idea can be pursued. Testing or reinforcing the student's ideas about where each line will cross the Y-axis (and the X-axis) can be done with the program SLOPE (see Figure 4). Consider the line X=Y as being

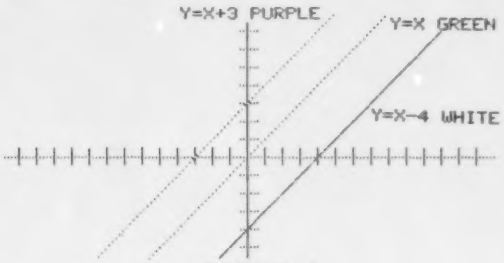

FIGURE 4

moved on the axes parallel to its position to either of the other two lines. Once it has been determined that the coefficient of X in the equation Y=MX+B tells the slope of the line, and students have discovered that "B" is the Y-intercept, then extending the impact of these ideas is critical. For example, students should come to see when lines are parallel and if they intersect. The relations that a teacher would like students to discover will be more apparent when the graphing is carefully done. Thus, in Figure 5 the graphs of Y=2X and Y=-1/2X <u>look</u> like perpendicular lines.

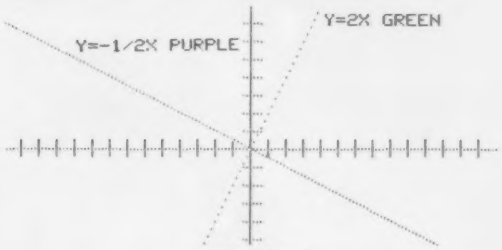

FIGURE 5

When using a computer that has dynamic capability (fast enough to keep interest, yet slow enough to see the graphing develop), many concepts can be pursued with more examples in a shorter time span. The program SLOPE can be used further to explore quadrilaterals in general or special kinds of quadrilaterals. In Figure 6 a parallelogram is graphed by drawing the lines for the following equations: Y=-X+1, Y=-X-4, Y=2X-3 and Y=2X+2. This is just the beginning to pursuing further the topics of coordinate geometry.

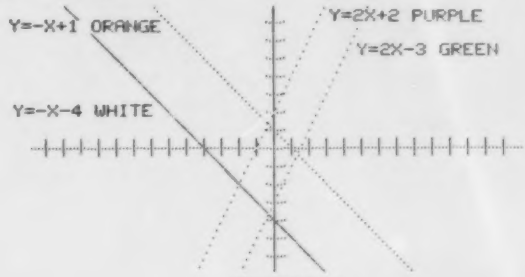

FIGURE 6

CONIC SECTIONS

Another program that can be used with an individual student or a total class to promote concept discovery is called CURVES. Capitalizing on the color graphics of the APPLE II microcomputer this program draws the straight lines that "sketch" the ellipse, parabola or hyperbola. A tutorial section within the program draws each curve a step at a time. The majority of the lesson is given to illustrations of several curves drawn within plane geometry figures.

Where elementary students do "curve stitching" in art class, the computer program CURVES will illustrate the development of composite figures. A geometry class will use this program to introduce conic sections and a pre-calculus student will enjoy the applications of conics in artful drawings. The title page in the computer program (see Figure 7) uses the caption AESTHEOMETRY, the term contributed by James T. Anderson in his book by the same name.

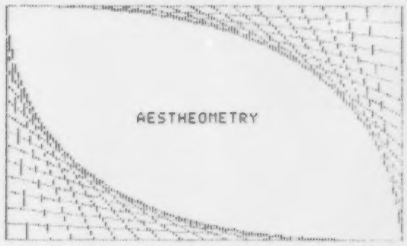

FIGURE 7

The student sees straight lines drawn by the computer, but when the figure is finished there is sketched a curve. Having captured the attention of the student, the computer program goes on to show how the curve is sketched. In a step at a time the figure is "built" within an acute angle. Then the steps are repeated for a right angle; finally the same procedure is shown for an obtuse angle. After the drawing is shown to reach that point where a curve is identified within the angle, the curve is given its name.

The program then illustrates combinations of these curves in figures that have been given names. In each drawing the initial plane figure is shown (a square or rectangle, for example) and then the straight lines are drawn which "sketch" the curve. Identifying with a name gives the figure a completeness. Figure 8 shows two of the six composites drawn in the program.

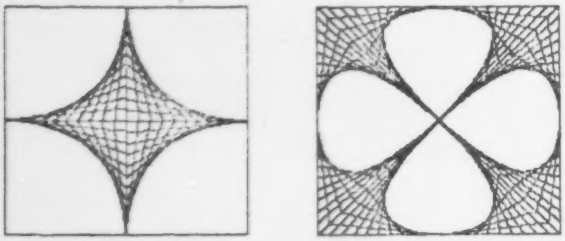

FIGURE 8

The computer program CURVES provides a student or a class the dynamic assistance to investigate curve sketching. With the self-contained computer system, a microcomputer, and its graphics displayed in color with a high degree of resolution, the learner has a powerful tool to discover relations and conceptual principles. Each step of the drawing can be left on the screen for as long as the student wishes and needs it. When the student wishes to run the program again and see the dynamic building of the curves, the same capability is available to do it all once more.

In Minnesota many schools are using the computer in the classroom to cover more material, while the student is surer of what is to be seen in the figure. Through the computer as a tool ideas are explored, theories tested, hypotheses formulated or discarded, and generalities revised that are the product of student investigation and discovery. Learning takes place in this environment that is part of the student for life.

COLLECTIVIZED

C.A.I.

Brother Austin David, FSC., Ph.D., Archdiocese of N.Y.

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ABSTRACT

The development of computer assisted instruction (CAI) materials, has tended to emphasize the individual instruction aspect of this instructional methodology. In this paper, the authors propose that such a methodology could indeed be used for group instruction. The recent developments in the area of microcomputers make such an approach feasible not only from an instructional viewpoint, but also from an economic viewpoint.

Recent developments in the fields of microcomputers and the communications technology interface with this computer capability, make CAI an attractive instructional tool. However, as with many recent technological advances, hardware developments tend to outrun software and in this case, courseware developments.

COLLECTIVIZED C.A.I.

CAI, Computer Assisted Instruction, is often considered an alternative to conventional classroom instruction and textbook study. As an assumed alternative, some research efforts have sought to measure the teaching and learning effectiveness of CAI against that of the traditional classroom instruction. The attitudes of students toward CAI have often been assessed against their attitudes toward classroom instruction (Blaisdell, 1976-77). And the cost effectiveness of CAI delivery has been compared to that of classroom delivery. In a way, the study and research has indirectly polarized CAI and classroom instruction so that some readers may find themselves being indirectly prompted to think that CAI is not just an alternative but a challenge to -- or even an assault against -- classroom instruction (Anastasio and Morgan, 1972). Is this actually true? Need this be so?

Central features that characterize CAI seem to focus on its highly individualized nature. The individual communicates with his lesson; CAI, in turn, communicates with the individual. In effect the student is tutored: the environment is "one-on-one", a feature that many would hold to be a hallmark of excellent instruction. The individual has privacy: for many students, because they are not "performing" before peers as in the class room, mistakes, errors, or poor decisions are therefore non-threatening. The individual's decisions and responses receive immediate attention: there is no classroom queing, with the chance that the moment of need is to be blunted or lost. In many instances learning activities are scaled to the individual's needs, to his responses. Individual needs are thus met and met immediately.

Classically, instruction has been delivered by two formal means, the classroom teacher and the textbook. The competent teacher is able to assess the moment, respond to change, re-direct, reverse, move ahead, restate, clarify, to respond to the many and the individual. Clearly, the teacher is dynamic. On the other hand, the textbook is static. It presents its material in a well-conceived, efficient, and structured manner. It is consistent: it remains the same, a constant. But individuals must be competent enough to take advantage of its static efficiency. The dynamic teacher, whose human performance may certainly not be as consistent nor as constant, can ad-

just to student needs. Textbooks present constantly with consistency; but they do not respond. Teachers present, not always with consistency, but they do so dynamically.

Because CAI presents and responds dynamically to the student, it is a far more powerful tool than the consistent but static textbook. Because CAI presents and responds in a constant manner consistently and immediately, it is often more powerful than the teacher, though not as dynamic. Thus, it would appear that, for the individual student, CAI appears to blend a powerful feature of the textbook -- consistency -- with a powerful feature of the teacher -- dynamic interplay. For the individual student, learning in an environment strong in both of these features would seem ideal.

But do we need to make such a choice? Certainly not! It would seem clear that, first, if one were deliberately to polarize CAI with another tool, it ought to be against the textbook, not against the teacher. CAI is a tool; so is the textbook. The teacher -- whose major function is to give instruction -- obviously has many other roles. One of these is to use or direct the use of learning tools effectively. But the teacher himself is not a tool of instruction. (Indeed, it would seem in one sense that excellent CAI might be defined as the best textbook content set in a mode to emulate the best actions and decisions of the best teacher models available). One role of the teacher is that of a decision maker, in a comprehensive manner concerning students, comprehensive in terms of the total student, all of his achievements and progress; directly in terms of skills and knowledge society deems important, but also in terms of his evolving personal emotional and social maturity as a unique person.

The teacher is not a tool. CAI is a tool, not another teacher: it is simply another tool that the teacher as a decision maker is to employ, a tool that emulates his dynamics far better than the textbook.

Assessment of learning progress is partly defined by an individual's gains measured not only against expected content and skill goals but also against the performance of peer groups, both present and past. In this sense, schools and teachers concern themselves with collective groups of individuals. Schools themselves are collective units, organized in one sense for efficiency in handling sets of tasks related to a learning population of individuals, in another sense for cost or economic effectiveness. For efficiency, in most instances, students are arrayed in schools by age or maturity, in classrooms to be directed collectively and individually by the classroom's teacher.

Some CAI ventures have addressed the collective needs of schools and teachers. These ventures provide the principal and teacher with records and reports of the individuals using the CAI in display formats to show both the individual's progress and that of his group. In a practical way this report generation capability removes from the teacher the need to handle clerical tasks that divert time and energies from far more important teacher roles. This praiseworthy collective feature is often put forward as a major aspect in CAI definitions. Because of its direct, practical assistance to the teacher, this emphasis helps overcome some reluctances where teachers may feel CAI is pitted against them as instruction givers. While worthy, this aspect is not at the core of CAI nor, even in our data gathering society, of significant importance for learning and teaching.

The "collective needs" of principals and teachers can be met in a far more significant manner. How? First, let us keep in mind that CAI is a tool to be used or directed by the teacher -- that it is not a replacement or a partial-replacement for the teacher. Second, let us suggest that not all learning need be "one-on-one", that, at times, learning as part of a group is indeed worthy, and, third, that various avenues to learning should not be "polarized", as if only one is to be available; that is, all tools and methods should be accessed and employed for their strengths.

Let's consider an extreme collective learning experience that is not employed daily in schools. Were we to receive a school guest of professional renown -- at any school level --, would we suggest that she or he talk to six students individually for 5 minutes each instead of speaking to a larger audience for a half an hour? Scarcely. Perhaps following the concept of the largest audience possible, we might arrange a seminar for a group of appropriate students. We would expect the speaker to reflect the moment, emotionally sustained in part by the large audience, and the large audience would, in a crass

sense, perhaps be our economic defense, as it were, for the speaker's fee.

Somewhat like the speaker, the classroom teacher instructs an audience too, but it is one he meets daily, one with its moments too, but one where consistency and replication are most important. What experiences does the elementary classroom teacher meet? Facing 30 students, almost continuously, through six hours, bounding from one subject matter or intellectual skill to another, each day's instruction differing from the last, he usually has no office, no phone to the world, no pause in the hall, virtually no lunch hour, and is deserted by fleeting time, confronting a diversity of subject matter and skills that ought to flow sequentially and developmentally. And there are fire drills, milk and lunch monies, galoshes, and childhood diseases. In sum, the teacher is put upon. Yet some believe that the elementary teacher is the professional most likely to adopt and adapt to the new and the future partly because he must ordinarily adapt to many events.

The elementary teacher gives significant time and effort to grouping (collectivizing) and individualizing instruction, despite having total group procedures. And, in general, the elementary teacher, unlike secondary and university colleagues, is daily more apt to face decisions about individualized and collectivized methods.

Organizing reading groups based upon student performance, for example, the teacher often uses several books or kits drawn upon for their strengths or specific purposes. Though he may create new materials, usually he must lean upon the design of others; indeed, if not, he would be overwhelmed by the time bounds and the diversities confronted. The elementary classroom teacher is not reluctant to use tools and materials designed and prepared by others nor is he reluctant to direct students to use these tools and materials individually.

Currently, there are numbers of schools now that provide CAI to their students. The literature suggests, however, though its availability is increasing, that CAI is not widely employed and that where it is, the accessibility within schools remains very limited. That is, there are far too few CAI stations serving far too many individuals. In a broad perspective, there are few instances where the classroom teacher can direct the use of this powerful tool with his students individually.

Should we not, at this time, be considering CAI as a "collectivized" tool rather than an "individualized" one. "Rather than" seems improper -- we needn't force either - or choices. Let's restate. Should we not be considering CAI, a collectivized as well as an individualized tool for the teacher. That is, CAI can be delivered to a class or class group through appropriate computer output devices by classroom teachers. Where output devices are not numerous, shouldn't we attempt to use them -- sometimes -- not always -- as efficient delivery systems for collective groups of students? Let's consider "Collectivized CAI" simply to be CAI presented to a group of students.

Instruction and learning are at the core of our concerns, as well as the teacher's. To the point: can we give the elementary teacher sets of CAI material for the classroom that he may use with groups (or whole classes) that would help with numbers, arithmetic, mathematics, spelling, vocabulary, reading, grammar, usage, and composition? Can we use available output devices and software for this? In many instances, yes; in some, no. What is our current CAI status?

The CAI doldrums we faced just two or three years ago has suddenly been replaced with a fresh breeze. The microprocessor has set us assail again, with new vistas. The micros certainly open up the vista for classroom based - teacher based -- computers; computers for both individualized and collectivized study and instruction within the classroom (Computer Store ----, 1975).

In the past we have faced some tight, hard, blunt fiscal problems in extending CAI commitment, however, significant research findings have proved its value or apriori logic has led us to value its unique and worthy features. CAI costs -- principally hardware -- have fettered our steps to advance its professional or theoretical status. Past fiscal -- not administrative or leadership -- problems have overwhelmed our ability to afford CAI, as defined by large mainframes. Admittedly, in a financial projection, a previous year's budget line tends to remain longer than newly proposed ones. New lines suffer serious attack and little broad support. The fight to gain new lines for CAI has been immensely difficult in the past

since the initial outlay needed has appeared so large before projected effective use could be expected. In turn, because there have been so few large scale CAI ventures, there has been no generally held, strong commitment to CAI even in theory.

But quickly now the microprocessor has shifted the battleground. No large initial budget lines are needed, as in the past. In a manner, CAI hardware can be phased in within more traditional evolutionary budget lines. As hardware, the micro appears cost effective. It is portable -- it needs no fixed space or significant space preparation with their sometimes hidden or latent cost, so again in one sense, it needs no costly attendants -- that is, professional staff members dedicated to its physical care.

By standards of the past, it would appear we should be able to phase micros into classrooms quickly. As commitment and experience grow, the phasing in of additional micros can be accelerated. The micro, unlike mainframes of the past, can enter schools quickly, gradually, and economically.

And as they enter in small numbers at first, they can be used for collective instruction by the teacher. The teacher need not be a bystander, sending his charges off to too few individual stations. The teacher can use the tool effectively and forcefully with his own presentations. The classroom teacher needs only one such tool. With one micro, CAI can be extended immediately to large numbers of students. (And it can be used by individuals too at other times within the classroom).

Quickly, one role of the teacher can be redimensioned immediately. He can extend his dynamic collective instruction with the additional dynamic but consistent and constant features of CAI. Appropriate micro output devices can spare him the task and time of writing on the board, for example. To a greater degree, he can concentrate on reception to be seen in the faces of his students, not being bound by more cumbersome tools like individual books and large wall charts. He can rely on the consistent mainstream of the CAI, adding his own unique commentary and notes prompted by his observation of his students and by their direct comments. He can spotlight and highlight and control the CAI's pace (Molnar, 1976). With ease he can replicate the essence of a lesson later, if need be. "Erasures" and "re-writes" can be instantaneous, in one sense. For the teacher-- and the student as well -- time and space can gain new dimensions.

With such systems as the NESTAR QUEEN and DRONES, multiple micros can be spread around the classroom or into adjacent classrooms to use gaming strategies as part of instruction. Various other media can be attached to the micros to develop alternate responses from the computer to the individual or group and vice versa.

Why a collective approach for the teacher and the classroom? Foremost, the relatively inexpensive hardware needed is here now. It is reasonable in price and can be cost defended. We can begin to phase in processors quickly, first for the teacher and his students, and then for students in number. Second, we will involve the teacher directly and professionally in both subject matter and its presentation, not tangentially as in reviewing data on student progress in past CAI. The teacher will gain a powerful tool to support and enhance his major role, providing instruction dynamically. In redimensioning his role, the teacher's involvement stands to strengthen his professional understanding and commitment to CAI, generally in a personal manner. This should prove a boon for individualized CAI, keeping the teacher concomitantly in a leadership rather than an "ignored" role. Three, if we accept the immediate reality of microprocessors being targeted for collectivized teacher employment (as well as for students), we may well turn to that real problem we have been masked from by past fiscal battles over hardware -- that of producing effective, transportable software that concerns itself with the common school branches.

Significant steps have been taken in numbers, arithmetic, and mathematics, at least in the form of games, if no other. Reading, vocabulary, spelling, and composition beckon us. We need not face the fiscal battle of machines -- that's virtually the past. Our new, true battleground is developing software for the microprocessor, for both individualized and collectivized learning. The development of one will impact the other, each very likely to add to the explication of the other's development, each complementary.

The development of microprocessor-delivered, collectivized CAI may be a

viable path to individualized CAI, its use enhancing the individual teacher, who will remain society's ultimate director of learning.

In a possible instructional scenario, a teacher with a micro, using video displays strategically placed around the classroom, could develop a lesson on a particular topic entering responses provided by the students to questions posed as part of the instructional strategy. Using some of the features available on micros, such as color or voice response, a multi-media blitz could be employed to highlight correct responses, or errors, depending on the strategy developed. Whether the topic is language arts or mathematics or whatever, instructional modules would be designed to exploit the evolutionary development of a concept or idea, using the "live-input", so to speak, of the learning audience. Choices and options could be explored "on-line" and dynamically with the micro as the teacher's tool controlling the developmental processes, but yet as viewed, and participated in, by the entire class.

Here we hasten to point out the potential which gaming and simulation strategies possess for instruction (Stephenson and Llewellyn, 1976-1977). Expanding the scenario presented above, let us assume that four micros were available within a classroom, and were tied to a central program/data file using NESTAR'S QUEEN or RADIO SHACK'S-NETWORK. The class could be divided into four teams which would explore various instructional strategies in competition. Groups of students would explore different areas, or the same areas of learning, developing the necessary skills to design their own learning strategies. Appropriate use of video and audio could intensify this process by keeping score, making progress announcements, etc.

Such a team approach to learning could have an impact on the socialization of learning. Such "team-learning", not unlike "team-teaching" in concept, could make a significant impact upon the real life situation where the cooperation and understanding of several individuals is often required to achieve a complex goal.

The above scenario is indeed most theoretical. Although the hardware elements necessary to give it life do exist, the courseware necessary to animate such a system does not exist. As with large scale technology, we again have the problem, "where is the courseware?". However, we believe that with the proliferation of microcomputers, especially in the home market, the courseware problem is rather different from the courseware problem experienced with large scale and minicomputers. The small scale technology has introduced a whole new forum of curriculum developers into the mix which was not present in the large scale developments of either industry or professionals tuned to education but knowledgeable in computer utilization. Now, the average instructional professional has the capability of experimenting with the technology and determining whether or not alternative instructional strategies could be employed. Perhaps, the attempt to use the microprocessors for instruction might lead to a closer examination of current educational theory. Perhaps it might be possible to cross disciplines and have a child study astronomy in French (David, 1973). After all, in France, they must have some astronomy courses which could be developed in a parallel fashion so that the knowledge of language and astronomy is developed concurrently. We have often been told that we can only "do one thing at a time". Experience seems to indicate otherwise, and the exploration of this possibility in instruction could be a benefit reaped from the attempt to use microcomputers as a tool of instruction.

To predicate where such technology might lead is impossible. Often with technology, it is assumed that the technology leads and man follows. Suffice it to say here, we went to the moon not because of our technology, but because of man's imagination. It is this imagination which will determine the future instructional utilization of microcomputers.

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Debugging the CAI User

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ABSTRACT

In a recent evaluation of a required PLATO laboratory simulation exercise for approximately two hundred medical students, the results showed aspects that could not be explained completely in terms of hardware and/or software parameters. It was noted that there seemed to be a correlation between this data and the Valence - Instrumentality - Expectancy Theory (Campbell and Pritchard, 1976). This paper develops the Expectancy Model for CAI.

INTRODUCTION

Many evaluations of CAI have concentrated on the capability of the hardware (e.g. graphics), the elegance of the software, or the relationship between these two (Figure 1). Since it is expected that the quality of the programs will have the most influence on user evaluations, most programs are developed and carefully debugged prior to implementation on a large scale. It is also recognized that reliable, well maintained hardware delivery systems are necessary ingredients of successful CAI efforts. Repeated crashes of the system frustrate users and adversely affect evaluations of CAI educational units.

We wish, however to call attention to a third system that can have a profound impact on CAI effectiveness - - the user system. Edwards (1970) and Goodman (1978) commented on this system. In particular, Goodman notes:

> Currently, among the factors least likely to be given due consideration especially in computer assisted instruction (CAI), are the "learning styles," "cognitive maps", and "sensory modality" or "media preferences" of students.

It is our thesis that the effective application of CAI requires careful debugging of this system as well. The balance of this paper will be devoted to development of a framework for analysis of user bugs. This will be supplemented by some practical suggestions which derive from our model.

The parameters of user bugs are depicted as amorphous (figure 1). User bugs are difficult to define. In order to lend clarity to our analysis, we will introduce an Expectancy Model of CAI utilization derived from a theory of motivation which has been successfully applied in industry (Campbell and Pritchard, 1976). Technically known as Valence-Instrumentality-Expectancy Theory, the model derives from the work of the psychological theorist Kurt Lewin (1936, 1938). Briefly, the model involves three elements. 'Valence' refers to a positive or negative quality of an object. As used here, valency is the positive or negative quality of a person's goals. 'Instrumentality' is the subjective probability that a particular activity will lead to the specified goal. 'Expectancy' represents the motivation or force that an individual employs while working toward the goal and is a function of valency and instrumentality.

The Expectancy Model of CAI Utilization is very simple in its basic application. In terms of the model, a CAI educational unit will be eagerly utilized by students (high CAI expectancy) as long as: (1) it leads to a highly valued goal (i.e. has high positive valence), and (2) the student knows that his work on the CAI program will lead him to the valued goal in a way that is considerably more efficient than any alternative route (i.e. has high instrumentality). The user

system has bugs (low CAI expectancy) whenever CAI users perceive (a) low value for the outcome of CAI, and/or (b) low CAI instrumentality in reaching their valued goals.

These fundamental applications of the expectancy model will be considered in some detail as they apply to student evaluations of a CAI program implemented at the University of Tennessee Center for the Health Sciences.

EXPERIMENTAL DESIGN

During the winter 1979 as part of the Biochemistry course, first year Medical students were exposed to a required laboratory simulation covering enzyme kinetics. Along with five hours of lecture and a three hour wet laboratory, the simulation was one of three teaching techniques utilized by the instructor responsible for the enzyme portion of the Biochemistry course.

Subsequent to the lecture and the wet laboratory exercise, students were required to work through a CAI enzyme laboratory simulation that was expected to take approximately three hours. A video tape describing the CAI laboratory simulation and the PLATO system was made available to students before and during the two week period in which they were to complete the simulation.

The CAI exercise was a simulation of a continuous, direct LDH enzyme assay in which the student could vary substrate concentration, enzyme concentration, pH, temperature and ionic environment. Resultant data was presented in graphic form as change in concentration of product vs time. Students could collect data from which they could estimate various characteristics of the enzyme such as Km, Vmax, specific activity, pH optimum, activation energy and thermal denaturation. After the students were familiar with the simulation they were required to evaluate the pH optimum and Km of a specific form of LDH.

Following the lecture, wet laboratory and laboratory simulation, students were given a short "Enzyme Quiz" covering material taken from each of the three phases of their exposure to enzymes materials. The quiz required them to draw conclusions from raw data.

Within a month of the quiz an attempt was made to get formal feedback from students concerning their evaluation of the CAI laboratory simulation portion of the enzymes segment of the Biochemistry course. The evaluation was carried out under the direction of the Computer-Based Education Advisory Committee. A free form instrument (a copy of which is included as an appendix) was circulated to 145 students attending an 8:00 lecture. No one associated with the Division of Computer-Based Education or the Department of Biochemistry was involved in the presentation of the questionnaire to the students. The Chairman of the CBE Advisory Committee explained to the students present that the purpose of the questionnaire was to get candid, honest feedback as to the efficacy of CAI methods such as had been used for the enzymes laboratory simulation. One hundred and twenty-six students responded to the questionnaire.

RESULTS

Responses to the questionnaire ranged from rave reviews to pointed denunciations. Responses could be clustered into six major categories:

1) time involved in doing the exercise,
2) interactions with the computer system,
3) problems of orientation to the terminal,
4) logistics of scheduling terminal time,
5) problems related to the program and
6) relevance of the exercise to the subsequent quiz

Responses in the time category varied. Positive responses indicated that a computer based simulation saved the student considerable laboratory and calculation time. Many students felt that a simulation was a time efficient method for observing the effect of altering variables involved in the enzyme assay.

Negative responses indicated that some students did not find the simulation worth the time required for them to complete the exercise. Several students reported frustration due to numerous central computer problems which occurred during the period of this exercise.

The two weeks during which the students were to complete the simulation coincided with a period of uncharacteristically poor computer reliability. For students unfamiliar with the normal incidence of problems, excess downtime became the norm.

Lack of familiarity with the terminal and the CAI system was a problem for some students. Some thought this was a negative aspect of the simulation, while others felt that an enforced opportunity to learn the system was a positive aspect.

With a limited number of terminals (one terminal for each fifty students) and a mandatory exercise, some logistical problems were anticipated. Unfortunately, these logistical problems were exacerbated by the increased down time

mentioned above.

Many comments dealt with the program itself. For some, there was the frustration of a fraction not accepted; for others there was the delight of the immediate results from a freshly conceived experimental permutation. For some the graphs were hard to read; for others the program relieved the drudgery of mathematical manipulations. Several were bugged by bugs; others were allowed to concentrate on principles.

Responses that mentioned the quiz were uniformly negative. There was an obvious misunderstanding among the students concerning the relation between the laboratory simulation and the material covered on the subsequent quiz. It was quite clear that very few students were willing to tolerate such misunderstandings quietly.

The majority of those questioned, however, reported that the exercise was worthwhile. When asked if they would recommend a similar exercise to a colleague, 62% of those offering classifiable answers indicated that they would (x^2 = 6.45, $p < .05$ assuming a 50-50 split expected).

DISCUSSION

Student comments elicited by the CAI evaluation are highly divergent. Many comments suggest that the experience was interesting and worthwhile. Other comments suggest the opposite. Is it possible that the same CAI program could be both tedious and fascinating, futile and functional? What sense can be made of these apparent discrepancies?

Our evidence suggests that some of the variance in student reactions is related to pronounced differences in the extent of prior experience with interactive computer operations. Some students with no experience expressed apprehension about attempting completion of the lab simulation. Knowing they were on unfamiliar territory, these students seemed to consider the CAI experience to be an exercise in futility. As a result, they never really got into the heart of the program. In other words, pessimistic expectations were rewarded with disappointing results. By contrast, many students who worked all the way through the program found it to be a very rewarding experience.

The central role of expectations in the example just mentioned brings us back to the model introduced earlier. A more detailed description of the model is now in order. Figure 2 presents an overview of the expectancy model of motivation. As mentioned above, the basic variables in the model are valence, instrumentality, and expectancy. The complexity of Figure 2 results from the fact that valence and instrumentality interact at several levels. Although this can be very complicated in studies attempting to quantify each variable, our discussion will be simplified because our application is primarily qualitative.

Figure 3 represents our application of the expectancy model to CAI. The model will be examined in detail flowing from left to right as we work through the steps of the debugging process. A left to right treatment of the model is only one way to look at it. In fact, we should note in passing that the students' perspective is best understood when the model is viewed from right to left. At the far right, we consider the students' underlying need to learn the material presented in the CAI unit. When the students perceive this need, we have a basis for motivation. Working to the left, we note that the level of student interest is a function of a number of variables, including several levels of instrumentality and valence.

Each of the elements in Figure 3 will now be considered. Using Table 1 as a guide, we will use the model to step through the process of diagnosing bugs in the CBE user system. This discussion will proceed from left to right, with question numbers keyed to the numbers associated with each element in Figure 3.

PRACTICAL IMPLICATIONS

Computer based education is not a closed system. It interacts with a number of other systems which greatly influence CBE effectiveness. One of these systems is the CBE user system. When the interface between the user system and the CBE system has bugs, the effectiveness of the CBE system suffers. Debugging the CBE user system is necessary to provide a fair evaluation of CBE effectiveness.

Several suggestions for corrective action are implied in our discussion of user system debugging. Basically, a user system can be debugged by raising the valence and instrumentality of CAI for system users. Since attempts to modify instrumentalities are more likely to have practical consequences than attempts to modify valences (Porter & Lawler, 1968), we will limit our suggestions to modification of CBE characteristics that relate to student's perception of instrumentality. The obvious place to begin is the instrumentality of CAI for student

needs (see Question 6 in Table 1). A CAI unit should not be implemented until its integration into the overall educational program has been planned in detail. If the CAI unit is the primary instructional medium for course content that forms an important part of student exams, the instrumentality of CAI can be raised. But this will only happen if the students perceive the link. The students should be able to predict with confidence just how much help to expect from the CAI unit.

Given high instrumentality for the content of the CAI unit, we can move backwards through the model to the instrumentality of CAI as an instructional technique (see Question 4 in Table 1). CAI should be used in those situations in which it can reasonably be expected to be superior to other instructional techniques. In the CAI program evaluated in this study, easy manipulation of parameters in the wet lab simulation was expected to be quickly recognized as superior to actual wet lab activities. Unfortunately, some students never saw it that way. For CAI to be effective, the student must become aware that the CAI unit is superior to other instructional alternatives. Student perception of the instrumentality of the instructional technique should be very carefully monitored to be certain that students are in fact seeing what they are supposed to see.

Finally, instrumentality can be raised at the expectancy level (see Question 2 in Table 1). If students predict that the CAI unit will take more energy, time, or information than they expect, they will be frustrated because their expectations have been violated. Advanced documentation of the time typically required to complete the program might help. These time estimations should be based on actual times recorded by students rather than an ideal estimate. A slight overestimate is far more acceptable than an underestimate. Similarly, students who are not confident in their use of interactive terminals should have good reason to believe that they will be helped when they need it. Otherwise, they may find the whole activity aversive and give up prior to reaping any beneficial consequences from CAI. When this happens, the CAI unit will be regarded as ineffective. Again, student anxieties about the CAI unit and student experiences in completing the unit should be very carefully monitored at this stage if the potential benefit of CAI is to be realized.

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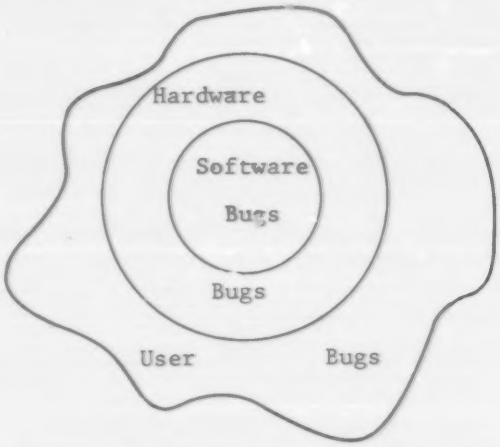

FIGURE 1 CAI Systems

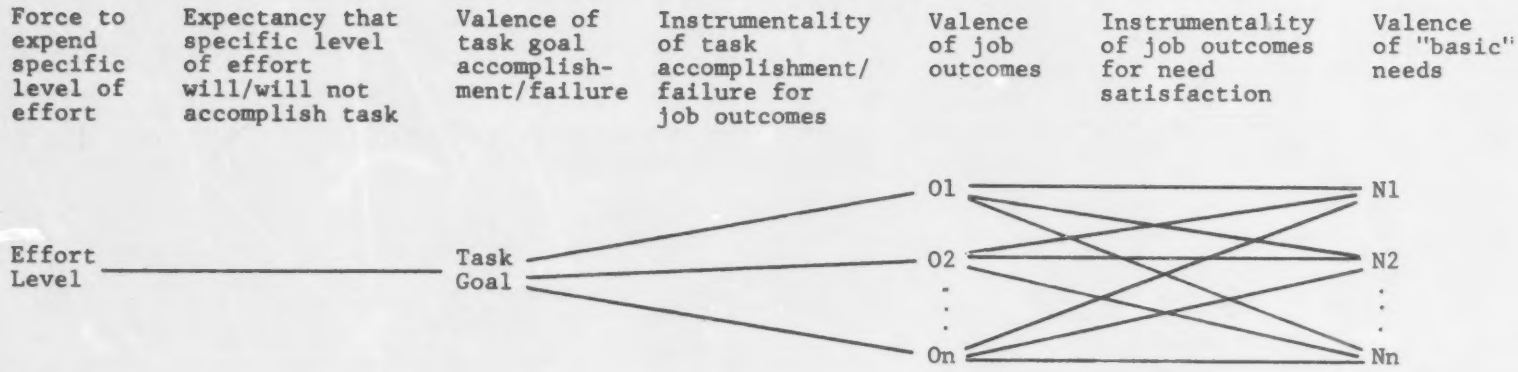

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FIGURE 2 Expectancy Model of Motivation

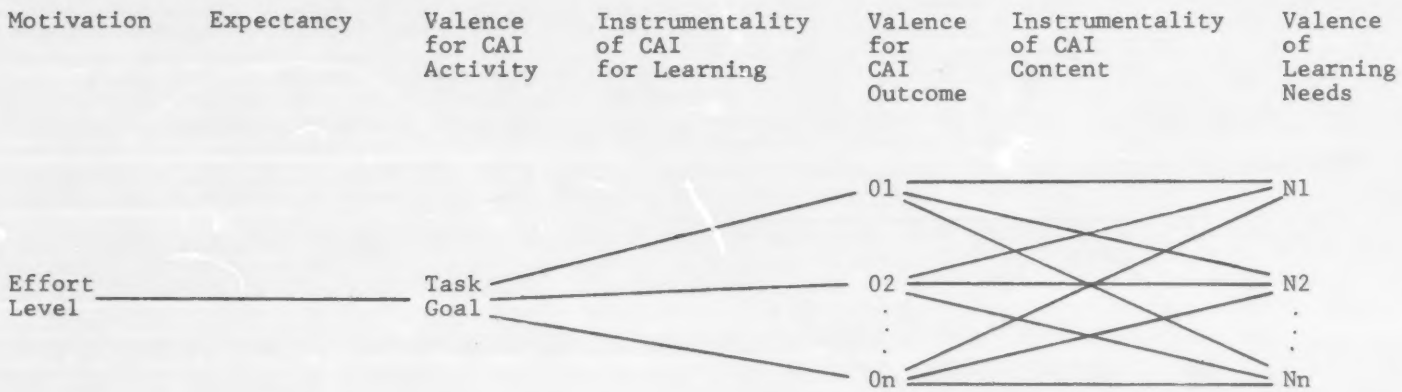

FIGURE 3 Expectancy Model Applied to CAI Utilization

TABLE 1 Guide to Debugging CBE User Systems

DIAGNOSTIC QUESTION	GUIDELINES FOR DEBUGGING	REPRESENTATIVE STUDENT COMMENT	ELEMENT OF EXPECTANCY MODEL
1. ARE STUDENTS ENTHUSIASTIC ABOUT CONTINUED USE OF THE CAI PROGRAM?	A. YES. STOP DEBUGGING OF THE USER SYSTEM IS NOT INDICATED.	"By playing around with the different parameters, it brought home some concepts better than looking at graphs alone. We thought up the experiment and the computer gave the results which we then interpreted. Thus, the lab simulation was better than I had anticipated."	HIGH MOTIVATION
	B. NO. PROCEED TO QUESTION 2.	"It was a waste of my time."	LOW MOTIVATION
2. ARE STUDENTS ABLE TO PREDICT WITH CONFIDENCE THE TIME, EFFORT, AND INFORMATION THEY MUST HAVE IN ORDER TO COMPLETE THE CAI PROGRAM?	A. YES PROCEED TO QUESTION 3.	"It was great to be able to work the various effects without having to graph, figure and work it myself. It was very efficient with respect to my time."	HIGH EXPECTANCY
	B. NO. STUDENTS LACK CONFIDENCE IN CAI BECAUSE:		LOW EXPECTANCY
	1) THEY MAY NOT BE FAMILIAR WITH THE CBE SYSTEM	"My main problem came from lack of knowledge about the computer and I also found some of the directions rather sketchy. Some of the things we did, I didn't understand until later."	NOTE: Expectancy can be raised by establishing a track record of high reliability with students. If students must rely on CBE with some frequency and find it is there when they need it, high expectancy can be developed.
	2) THE SYSTEM ITSELF MAY HAVE BUGS	"It took 4 sessions of 3 hours each to get through the program. Not because I could not understand it but because the darn thing kept breaking down."	
	3) STUDENTS MAY HAVE DIFFICULTY ACCESSING THE SYSTEM.	"With limited time medical school and 200 people trying to use 4 PLATO terminals and the terminals going out periodically, it was a headache."	
3. IS COMPLETION OF THE CAI PROGRAM AN ACTIVITY THAT STUDENTS THINK IS VERY WORTHWHILE?	A. YES. CHANGING THE VALENCE IS NOT INDICATED. PROCEED TO QUESTION 4.	"Plato provided a brief and efficient method for observing the effect of altering the various variables involved in an enzyme reaction."	HIGH VALENCE FOR CAI ACTIVITY

3. (cont.)	B. NO. STUDENTS MAY NOT VALUE CAI FOR ONE OR MORE REASONS:		LOW VALENCE FOR CAI ACTIVITY
	1) THEY MAY FIND THE CAI ACTIVITY TO BE INHERENTLY UNPLEASANT AS A LEARNING MEDIUM.	"Problems involved punching in values, etc.--very difficult to a non-computer minded person like me."	NOTE: Computer based games and graphics might be used to stimulate students acceptance, especially among students who never become accustomed to interaction with a computer terminal.
	2) THE CAI ACTIVITY DOESN'T SEEM TO BE USEFUL. THIS IS A FUNCTION OF INSTRUMENTALITY PROCEED TO QUESTION 4.	"It really didn't help too much. It seemed to be mainly an exercise in plugging in numbers to get some specific response which wasn't meaningful."	
4. DO THE STUDENTS THINK THAT COMPLETION OF THE CAI PROGRAM IS THE BEST WAY TO LEARN THE MATERIAL?	A. YES. GO TO QUESTION 5.	"It allowed me to see the changes in pH and temperature without spending hours in the lab.	HIGH INSTRUMENTALITY OF CAI FOR LEARNING
	B. NO. STUDENTS MAY NOT FIND THE PROGRAM HELPFUL BECAUSE:		LOW INSTRUMENTALITY OF CAI FOR LEARNING
	1) THE PROGRAM DOES NOT HELP THEM LEARN	"The experience was quite unstructured, and therefore, quite confusing."	
	2) OTHER WAYS OF LEARNING ARE SUPERIOR TO CAI.	"Plato is fun but it takes too much time. I think 10 minutes with an instructor could have been much more helpful than 12 hours with PLATO."	
5. DO THE STUDENTS THINK THAT CAI WAS A LEARNING EXPERIENCE?	A. YES. STOP. NO FURTHER DEBUGGING OF USER SYSTEM IS INDICATED.	"Being able to attempt the answer by trial and error appeared to engrain the concepts into my thinking. It definitely helped me on the quiz and in my overall knowledge of enzymes."	HIGH VALENCE FOR CAI OUTCOME
	B. NO		LOW VALENCE FOR CAI OUTCOME
	STUDENTS MAY NOT REGARD CAI AS A SUPERIOR LEARNING EXPERIENCE BECAUSE:		
	1) THE MATERIAL IS OF NO INTRINSTIC INTEREST TO THE STUDENT	"I really didn't get that much out of it. I really didn't understand what I was doing."	

5 (cont.)	2) THE MATERIAL IS NOT USEFUL. AGAIN, THIS RELATES TO INSTRUMENTALITY. GO TO STEP 6.	"In regard to testing, it did not help me in the slightest way. I thought it was interesting and meaningful but obviously the instructor did not think that the lab had any use whatsoever."	
6. DO STUDENTS THINK THAT LEARNING THE MATERIAL IN THE CAI PROGRAM IS THE BEST WAY TO SATISFY THEIR NEED TO LEARN?	A. YES. GO TO STEP 7.	"Helped with 'picky' questions about maximum pH for the LDH reaction that were given on the test."	HIGH INSTRUMENTALITY OF CAI CONTENT
	B. NO. THE STUDENTS MAY NOT SEE THE MATERIAL AS HELPFUL BECAUSE:		LOW INSTRUMENTALITY OF CAI CONTENT
	1) THEY ARE AWARE THAT THE MATERIAL IN THE CAI PROGRAM WILL NOT HELP THEM.	"It had nothing to do with the concepts of the testing so that as a helpful study guide I would rate it as less than worthless."	
	2) THEY ARE NOT AWARE THAT MATERIALS IN THE CAI PROBLEM WILL HELP THEM.	"PLATO did not prepare me very well for the quiz on problems that listed substrate concentrations and Vmax. In short seeing an array of data in this form seemed different from the PLATO experience."	
7. DO THE STUDENTS HAVE A STRONG NEED TO LEARN?	A. YES. STOP. FUTURE DEBUGGING OF THE USER SYSTEM IS NOT INDICATED.	"Time is so very much at a premium at this point, each lab should be double and triple checked with a truly critical eye to see that it warrants the time, both in and out of class, that will be required. "Cookbook" labs, or 'Just for the hell of it' labs, or 'Just because it is interesting' labs are a waste of time--we just have too little of it to waste."	HIGH VALENCE OF LEARNING NEEDS.
	B. NO. YOU ARE IN THE ENTERTAINMENT BUSINESS. WHAT YOU NEED IS GOOD SHOWMANSHIP.	(none in our sample)	LOW VALENCE OF LEARNING NEEDS.

ATAP: A MODEL FOR INTERACTIVE COMPUTERIZED TESTING AND RECORDS MANAGEMENT AS AN INTEGRAL PART OF A SELF-PACED ANATOMY AND PHYSIOLOGY COURSE

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ABSTRACT

A self-paced course can be substantially aided by a computer program that is closely integrated into the structure and philosophy of the course. Audio-tutorial anatomy and physiology (ATAP) is a large, self-paced laboratory science course designed to meet the needs of students in health-related areas.

The course content is divided into weekly units that a student learns at his own pace. There is a unit test, review test, and an oral quiz over each unit. Testing is mastery oriented and a student must pass one unit before proceeding to the next. A sophisticated computer program has been developed as an integral part of the course to handle most of the functions of testing, retesting, and record keeping, as well as mangement functions. Testing is done on interactive computer terminals and students receive immediate feedback as to correctness of response. Several innovative approaches are described that were developed to encourage mastery learning and retention, to reinforce learning during testing, to deal with test security, to help students cultivate the self-discipline to maintain regular study habits, and to provide a continuous record of the student's progress in the course. Although the program was developed for a specific need, the model is flexible and not content-dependent and has the potential for application to other subject areas.

INTRODUCTION

One of the most important ideas in education to be widely implemented within the past two decades is the concept of self-paced, or programmed instruction. The concept has evolved to mean that the student works essentially at his own rate as he progresses through carefully designed units of course content. Behavioral objectives are usually included to inform the student of exactly what is expected of him and the testing often tends to be mastery oriented.

Different approaches to the presentation of material have been used within the self-paced format. One of the first was developed by Postlethwait at Purdue University in 1961. (Postlethwait et.al, 1964) Using his "audio-tutorial" approach, the students were individually tutored in botany by weekly tape recordings that guided the student through a series of laboratory exercises and demonstrations which were correlated with a study guide and outline. Students were provided objectives and could work at their own speed to complete the weekly unit.

Fred Keller (1968) developed his approach to personalized self-paced instruction (PSI) that used the printed page to guide the students, provided assistance through student tutors, and emphasized mastery learning of the material. Interactive computer programs were soon developed to guide and to teach. The concept of self-paced instruction has since been successfully applied to many courses on many levels. The different approaches to self-paced instruction have been implemented and modified in accordance with the nature of the subject matter, the interests of the instructor, and the available resources.

A sufficient number and diversity of self-paced courses have been evaluated to suggest that perhaps significant progress has been made in techniques of teaching. In comparison with traditional courses,

self-paced courses are nearly always rated higher in student attitudes. Achievement, performance, and retention are often reported to be higher than in conventional courses. (Kulik et.al., 1974, Hinton, 1978) (Negative comments about self-paced courses are sometimes heard from instructors and usually relate to the amount of time required to establish such a course!)

Self-paced courses often emphasize content mastery, that is, a student does not complete a unit until he demonstrates competency by achieving the criterion or minimum score on a test over that unit. Consequently, there is often much testing and retesting. The use of a computer to score tests and to generate multiple forms of a printed test from a bank of items has been tried in traditional courses. Interactive computer assisted testing, usually with feedback as to correctness of response, has also been developed as an adjunct to conventional presentation of course content, but it appears that only a few self-paced courses with interactive computer testing have been developed.

To design a computer program for testing and record keeping that becomes an integrated component of a self-paced course requires the close cooperative efforts of the programmer and the instructor. The program must be able to accommodate and to enhance certain philosophies of instruction and testing that are not found in conventional courses. In this paper we will describe the planning, development, and implementation of a large, introductory, self-paced anatomy and physiology course and the co-development of an innovative computer program for testing, record keeping, and evaluation.

NEED FOR SELF-PACED FORMAT

Anatomy and physiology at The University of Akron is a large, traditionally taught, introductory laboratory course which is taken by students preparing for physical education, nursing, medical assisting, and other allied health fields. The course was originally designed for nursing students, but as other groups were added, the diversity of academic background became apparent. Increasing numbers of students with weaker backgrounds were floundering and a few of the stronger students felt their time was being wasted by being locked into the traditional lecture and laboratory course aimed at the "average" student.

One solution to this would have been to establish different anatomy and physiology courses for each specific group of students. This approach, unfortunately, can lead to a series of watered-down courses and is generally more expensive in terms of facilities and salaries.

Instead of creating multiple courses, the conversion of the existing course from a traditional format to a self-paced format would meet the need of the different programs and yet not penalize students who had less science preparation. Self-pacing would give these students additional time and opportunities to learn the material. With the construction of a new nursing and allied health building, the opportunity was provided to design any special facilities that would be needed for a self-paced course.

THE AUDIO-TUTORIAL APPROACH

The particular approach to self-pacing that was selected was audio-tutorial because it offered advantages for this course that a self-paced manual or computer terminal alone could not. It was desirable to closely integrate the hands-on laboratory portion of the course with the lecture-content portion, therefore the format would have to be compatible with a laboratory setting. Vocabulary is a basic part of anatomy and physiology and it was important that the student hear words pronounced correctly and be given the opportunity to pronounce them. Since key words are printed in the study guide and since many visual aids are used, the tape makes use of hearing as another sense modality to reinforce the material. With the ready availability of cassette recorders, it would be possible for students to review the tapes at home or in the car. Last but not least, the voice on the tape is one that the students can readily identify with the instructor, much more so than with a printed page or terminal. This reduces the feeling of depersonalization that can develop in large courses using only printed materials.

AUDIO-TUTORIAL ANATOMY AND PHYSIOLOGY (ATAP)

The laboratory exercises, tapes and study guides were developed, tested, and revised last year using a pilot group of students. The overall course content had been rather clearly defined by using objectives that were prepared by the instructor in consultation with advisors representing the various groups of students. During this time, planning began for the ways in which the computer facilities and the services of the Computer Based Education Center could most effectively be used.

The new physical facilities for the ATAP Learning Center were ready this past

September, and the new approach was implemented. The large open laboratory has fifty-five tape recorder-equipped carrels around the perimeter of the room and an extensive demonstration table/work area in the center. There are adequate storage and preparation areas and the computer terminal room is located nearby.

The Learning Center is conducted as an open laboratory. Students may come and go as they please and may spend as little or as much time as necessary to master that unit's material. The voice on the tape tutors the students individually through a sequence of discussions and activities designed to help them master the content of that unit. Activities may include reading a section from the text, preparing a microscope slide, dissecting preserved material, watching a videotape, performing an experiment, or studying charts and demonstrations. A faculty member or graduate assistant is always available to respond to questions and to provide help.

In addition to the self-paced study in the Learning Center, the class meets as a group once a week with the instructor in a General Assembly. This time is used primarily for course enrichment activities such as special films, guest speakers, additional topics of interest that elaborate on the tape content, and to take care of organizational matters.

The course content is divided into self-contained units or modules with each one representing a week's work. Although a new unit is set up in the Learning Center each Monday, the previous unit remains available for another week. Students are expected to complete their study of the unit during the first week but if illness or other circumstances prevent this, the unit is available to them a second week.

The students are evaluated over each unit's material by a weekly oral quiz and a written quiz presented on a CRT terminal The oral quiz is given at a scheduled time by a graduate assistant to a group of six or eight students and focuses on identification of anatomic models, demonstration of techniques, and correct use of vocabulary. The computer test is available at the student's convenience and focuses on facts, concepts, and applications. A student must achieve 70 percent or more on a unit test before going on to the next unit.

This format provides the student with considerable flexibility. The only formally scheduled activities are the General Assembly, which is sometimes optional, and the half-hour oral quiz. The times for the three to five hours of independent study and the computer testing are at the student's convenience and may vary from week to week. A new unit is presented on Monday and by the middle of the week most students have begun working on it. The General Assembly on the following Monday reinforces the studying done over the weekend. The oral quizzes are scheduled that Monday or Tuesday and the computer test is available the week the unit is introduced and for two weeks afterward.

Although ATAP is not completely self-paced, it does offer the student much more flexibility in his learning pace than does a traditional course. In a completely self-paced course, the student would be able to work as rapidly or as slowly as he wishes over the entire course content in order to master the objectives. He would be able to move from one unit to the next with essentially no time constraints. The ideal is seldom recognized in practice. A laboratory course involves a variety of exercises utilizing reagents, equipment, models, living and preserved materials, and demonstrations. It would be logistically impossible to have all exercises set up throughout the semester to serve a large number of students. Consequently, the laboratory portion of a self-paced course places some restrictions and deadlines on the student's progress. Such restrictions are not necessarily undesirable. A completely self-paced course requires a level of self-discipline to keep up with the work, a characteristic that is rare in most freshmen. A flexible laboratory period with reasonable deadlines appears to be an appropriate compromise that may help promote student efforts toward completion of the course.

NECESSITY FOR COMPUTER ASSISTANCE

If a student does not demonstrate mastery of the material on the first test, he needs to review the material again and take a retest. If not successful, help is provided and the student works with the material until he is able to achieve 70 percent on a unit test before he is permitted to proceed to the next unit. The preparation of multiple forms of a test over a unit would be a good application of the computer because of the ability to generate different tests by randomly selecting items from a bank of appropriate questions. The test items could be matched to specific objectives and stratefied with respect to level of difficulty. With an interactive computer terminal, the program could also provide the student with immediate feedback as to the correctness of his response.

Although some individuals feel that testing via a computer terminal may not be

appropriate for reasons of security and psychology, we feel we have identified the potential problems and have devised a computer testing format that is both acceptable and effective in testing as well as providing some reinforcement of learning. We will describe the testing program later in detail.

The present course has over 350 students and next year will be combined with another section of anatomy and physiology which will double the enrollment. Record keeping for 700 students in a traditional course even using computer graded op-scan sheets is rather time consuming. In a self-paced course there is often a much greater number of scores that contribute to the final grade because tests are given over smaller units of material and opportunities for retests are available. By way of comparison, the traditional anatomy and physiology course had ten scores per student, but ATAP will average well over 60 scores per student. In addition to weekly unit and review tests which may be repeated, there are weekly oral quiz scores to be recorded and occasional bonus points awarded for additional work. The op-scan system with the type of maintenance it requires would be too bulky and cumbersome for ATAP and would not have the desired flexibility. A brief survey of large self-paced courses at other institutions that did not have a sophisticated computer program for test administration and record keeping found that approximately one full-time secretary was required per 900 students.

FUNCTIONS OF THE COMPUTER PROGRAM

The computer program (also called ATAP) has three major functions: 1) testing while reinforcing learning, 2) record keeping, and 3) encouraging the development of self-discipline which will help the student to stay current. ATAP's first and main function is to test, unit by unit, the student's acquisition of knowledge of anatomy and physiology and at the same time to reinforce learning through the use of corrective feedback. The large enrollment of this course and the lack of adequate clerical support made the second function of this program, record keeping by computer, a necessity. This function has turned out to be somewhat innovative. The capability for motivating the student to complete his work on schedule is also built into this program by awarding additional points for punctuality toward the course grade.

ORGANIZATION AND USE OF THE TESTING MODEL

The data bank for the model has a capacity of containing over 24,000 items. ATAP was constructed from a base of approximately 900 objectives (30 objectives for each of 30 units) developed previously by the instructor for the anatomy and physiology course. Each test item is keyed to one of the 900 objectives and further classified according to three different levels of knowledge expected for correct response. (See Figure 1)

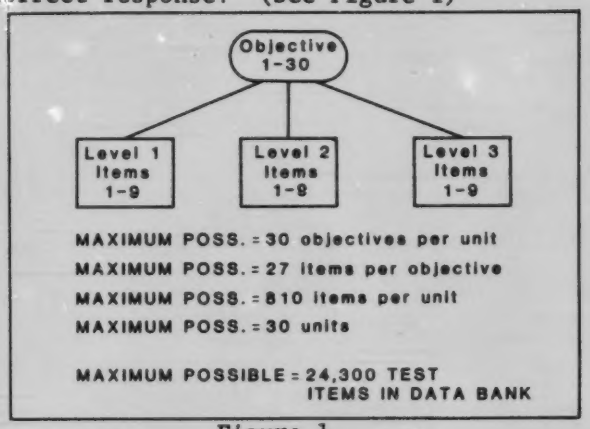

Figure 1

The three levels of knowledge used for the classification of the test items are: 1) the information level--in which the student needs only to be able to recognize or recall a piece of information, 2) application and comprehension level--in which the student must demonstrate enough understanding of the material to be able to generalize and apply facts to other situations, and 3) synthesis and evaluation level--in which the student must demonstrate the ability to use the knowledge he has gained from different areas to formulate new concepts.

Two types of tests are generated by the model; a weekly unit test and a review test. The unit test determines whether the student has achieved at least a minimal mastery of the content of a particular unit. If a student does not earn at least 70 percent on the unit test, he must continue to retest until passing the present unit. This is necessary because the units are not independent of each other, but rather build successively on one another. To insure that the student can build upon previous knowledge, a minimal score is required. Once the student achieves over 70 percent, he may retest over the same unit with the intent of raising his score. The highest score earned is the score which is eventually recorded.

A review test is given immediately after the unit test on which the student

has scored over 70 percent. The review test consists of 12-15 randomly generated test items from the immediately preceding two units. A review test is given only once for each week's unit and may not be retaken. The purpose of the review test is to encourage longer retention through repeated exposure to the material and to help differentiate, on a grade basis, between students who "cram" to pass a unit and those who have a more permanent grasp of the material. (See Figure 2 for flow chart)

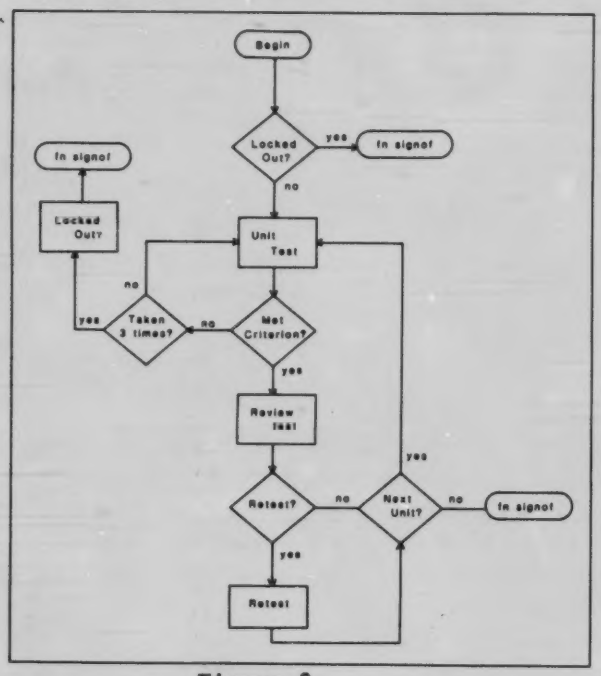

Figure 2

The final grade in the course is based on the total number of points earned by the student throughout the course. For each unit the student can earn up to 30 points for the unit test and 30 points for the review test. In addition, points are earned from an oral test which is given (not by computer...yet) to test practical knowledge of anatomy and physiology and vocabulary. A maximum score of 10 points for each oral quiz is given. Punctuality points are also given for each unit if completion occurs before a date previously determined by the instructor. All of these scores are stored in the student's record.

The reduction of test anxiety was an important factor considered in the development and use of this testing method. One method used to reduce test anxiety is to allow the student who has given an incorrect response to a test item and immediate, second opportunity to respond to the same test item. If he chooses the correct response the second time, he receives half-credit for the item.

Another technique used to reduce anxiety and to also reinforce learning is to provide immediate feedback to the student regarding his choice of answers. If the answer chosen is correct, the immediate feedback tells him it is correct and provides some additional information about the correct answer. If the answer chosen is incorrect, the student receives immediate feedback which tells him why the answer is incorrect. Because of this help, the second attempt on a test item is worth half-credit.

Test security is a potential problem in any large class and it may be somewhat compounded by the use of CRT terminals for testing. The model provides for safeguards and procedures that will provide at least the level of security which is usually found in other classes in which pencil and paper testing is used. The security measures used in the ATAP model are of two types: 1) Those that are external to the program, and 2) those that are internal. The external security measures are the responsibility of a student monitor in the terminal center. Each student who wishes to take a unit test must present his University ID card to the monitor. This ID card, which has a picture of the student, assures that the student taking the test is the correct student. The monitor signs on to the program with a special number and enters the student's sign-on number and a password. This procedure is checked by the computer program and a switch is set which then allows the student to sign-on.

The internal security measures are those things which the program itself does to promote security. Initially, plans were to develop a series of personal data questions, the answers to which would be stored in the student's record. When the student comes back to take another test, several personal data questions would be randomly selected and presented to him. His answers for this sign-on would be compared to the answers stored from his initial sign-on. If all of the answers do not match, the student would then be asked to check the correctness of his sign-on number and the program would sign him off. Because of time constraints we did not complete this section. After the first semester, we found only minor problems with test security, none of which had to do with students signing on with someone else's number, which we thought the personal data questions would prevent. We decided that this security measure was not necessary,

at least not at this time. An internal measure which is used presently is the setting of a parameter which prohibits the use of the printer to produce copies of the tests and prohibits the use of any other kind of terminal except the CRT.

Each test item for every test is randomly selected, dependent on objective, level, and item number. This random selection of test items is a very good security measure itself. This means that no student is likely to receive the same test as any other.

ENCOURAGING SELF-DISCIPLINE AND PUNCTUALITY

Procrastination is a human failing which is observable in traditional classes but it is especially evident in self-paced classes where deadlines do not seem so ominous. Various motivational techniques are used in this course to keep students from falling too far behind. Weekly testing makes it apparent to the individual student whenever he does not complete the recommended amount of materials in the suggested time. The reporting system, which will be discussed next, makes it possible for the instructor to monitor the progress of the students and to offer help to those students who are not current in their work.

Another technique we have devised to encourage punctuality is to reward the student with points whenever a unit is completed within the recommended time. The number of punctuality points is calculated and entered in the student's record by the computer program. Only if a student has both a review test completed and an oral quiz score recorded and verified by the graduate assistant before the recommended completion date for the unit, does he receive punctuality points.

MANAGEMENT AND RECORD KEEPING

As well as being a testing program for the students, ATAP is an instructional manager and gradebook for the instructor. The model provides a means by which the instructor can set many of the variables of the testing program, obtain various student progress reports, and enter scores in the student's record. Each year as the instructor begins his course he can register his students into the computer program. Sign-on numbers are automatically assigned during this registration process and individual student files are prepared. During the registration process the instructor also can assign students to small group sessions by entering a group code for each student into the computer program. This small group assignment is available to provide for more manageable groups in which the graduate assistants may administer the oral tests and to allow for weekly discussion of the material. At the conclusion of this registration process, the instructor will have available two class rosters; one for the entire class, and one divided according to the oral testing groups.

The management program allows the instructor to set a number of variables for each of the units. The instructor can choose, for example, which of the 30 objectives shall be represented on the test for each unit. He can decide how many items from the three learning levels are to be presented in each test. He can alter the criterion level for each of the units. He can also determine the exact dates that the unit is to be presented and when the material for the unit should no longer be made available to students. All dates that the instructor selects are checked each time a student takes a unit to verify the student's eligibility for punctuality points.

This capability for altering testing variables contributes to this program's great versatility. For example, variables can be changed from year to year, or from semester to semester as an instructor observes differences in class make-up and skill levels. The variables could be set differently for different classes, if more than one class were to be taught, and in fact could be adjusted in many ways to benefit both students and instructors in the learning-teaching process.

As students progress through the units of the course, much information is collected and stored in each student's record. All of the scores from the unit and review tests are stored as well as the number of attempts each student takes to reach the criterion level established by the course instructor. Upon reaching criterion, that attempt number is also stored. If a student does not reach criterion after three attempts, the program prevents the student from continuing until he has had a conference with a tutor. This lockout is recorded in the student's record and the student cannot continue until released by the tutor after a conference.

By entering the appropriate one-word command, the instructor may obtain these collected data in the following formats:

1. a list of all students who are required to have conference but have not yet had one

2. a grade report for all students for all units
3. a grade report for each of the oral testing groups
4. an individual report.

The individual student report is available to the student, instructor, and graduate assistant at all times, while the other reports are available only to the instructor and graduate assistants.

Many times a situation may arise in which the instructor feels it necessary to alter a student's grade. A question might be misunderstood by the student, the question may have contained erroneous information, or some other similar situation may arise. Changing a student's grade is possible using the management system. A variety of other data collected from the student can be altered by the instructor via the management system, such as the student's name, group code, etc. The command to alter data is restricted to the course instructor only.

CONCLUSION

ATAP is an attempt to enhance the teaching-learning experiences in a very large self-paced, audio-tutorial course in anatomy and physiology at The University of Akron. It attempts to present a great quantity of course material in a very versatile and potentially ever-changing format. It attempts to provide up-to-the-minute information about student progress and student grades without an increased dependency on clerical support. It attempts to encourage at least minimum competencies in information and skills, which are classified into several levels, and it motivates punctual student performance. Finally, it attempts to reinforce learning even during the testing phase of the course.

ATAP is presently proving to be a useful teaching-learning device at Akron, meeting the standards of its course author-instructional programmer team. And because the model was designed to be extremely flexible and content-independent, ATAP holds out the possibility for future development in many other disciplines.

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DATABASE MANAGEMENT SYSTEMS IN PHARMACY INSTRUCTION.2.

AN APPLICATION TO THE DRUG DISPENSING LABORATORY.[1]

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One of the fundamental skills to be learned in Pharmacy professional education is that of drug product dispensing and compounding. While only a part of the total professional curriculum, it is probably the most visible and easily identifiable of the pharmacist's professional skills by the lay public. The series of steps that constitute the dispensing process usually begins with the receipt of a written prescription and ends with the presentation of the medication to the patient along with instructions for use. Between these delimiting steps are several discrete observable activities, some of which are (1) interpretation of the prescription notation, (2) retrieval of the stock container, (3) measurement of the correct dose, (4) production of a suitable label containing essential as well as useful prescription information, and (5) updating of the patient medication record. Several less observable yet important activities also must occur during the dispensing process, one of which is confirmation of the prescription order to assure its compatibility with available dosage forms. A second activity is the consideration and minimization of any potential drug interactions, both when filling multiple prescriptions and when updating the patient medication record.

While the physical operations are usually not difficult to master, the less visible operations are not easily learned. One probable reason for this is the lack of similarity between an academic laboratory and a clinical setting. One instructional approach, an apprenticeship in a community pharmacy, is seldom practical or educationally appropriate in the early stages of learning. The more usual approach has been to use a file of prepared prescriptions, a subset of which is selected by the instructor and assigned during each laboratory period. Generally, the dispensing laboratories follow a learning sequence based upon therapeutic class. For example, cardiovascular drugs are covered during one time period, sedatives covered in another, and antibacterial agents considered in yet another. The order in which the therapeutic classes are considered in the laboratory often parallels coverage in an accompanying series of lectures. To create a dispensing laboratory experience that simulates the actual practice setting, the instructor needs to generate at least three or four unique prescriptions per student per week. If the student is to experience the use of the patient medication record, there must be several prescriptions per patient; when taken in total they must represent a realistic medication profile of each person's disease state and therapeutic course. Ideally a class of 100 students would require 3000-4000 individual prescriptions. Such a large number of rationally designed orders is difficult if not impossible to generate and maintain within the constraints of the laboratory and teaching resources.

The management of this instructional environment is a task ideally suited to a computer-based approach and at least one effort has been made to implement such system using classical file design techniques (Irgens, 1975; Crahan, 1977). While that system provided an ample supply of unique prescriptions, the apparent random nature of retrieval and generation processes was a significant shortcoming. With any such system misassignments are possible. For example, oral contraceptives

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[1] Part 1: Henkel, J. G. and Wilkinson, L. 1979. Toward the Development of a Computer-Managed Instructional System in Pharmacy, Based Upon Integrated Database System Concepts. Proc. Nat. Educ. Computing Conf. June 25-27, University of Iowa, Iowa City, IA, pp. 360-370.

can be assigned to males and antihypertensive medication to young children. Such problems are correctable through complex software and a series of indicator variables that make the system quite cumbersome to manage.

An alternative approach utilizes a commercial database management software package, System 2000[2], to simulate a large patient population. Database management systems, extensively used in business and industry, represent a significant development in the manner in which data resources are organized, stored, and utilized. The concept has evolved from the viewpoint that collectively, the data pertaining to any organization are its most important manageable resource. Thus, the organization itself can be reflected and completely represented by a centralized store of well-organized data. Moreover, management based upon this store of data is represented to be more effective than that based upon more traditional approaches (Davis, 1974; Davis, 1976; Ross, 1978). In this centralized environment, several important changes occur, one of which is the integration of the data to accurately define the logical characteristics of the organization. A second change is reduction of data redundancy as each datum is stored in only one place and then shared or accessed in multiple ways. Other changes include concomitant increases in data integrity and security. In the database concept, software is developed to organize, control, store, update, and retrieve data in the integrated database. This database management system (DBMS) assumes nearly all of the usual functions of file processing and data storage. Data are addressed by logical addresses rather than specific fields, the logical organization of the data may be modified automatically, and more data may be added without concern for where or how it is physically stored.

Although the integrated database approach is widely used in the data processing field, few investigations of its applicability to instructional environments have been reported. To our knowledge, our own Instructional Management System (Henkel, 1979) is the first attempt to manage a nontraditional educational environment with a CMI system based on database concepts. Herewith we report a second system using the database approach, the Prescription Simulation System (PSS), designed to serve as the basis for a course in drug dispensing. While presently limited in scope, we believe the approach holds promise for many similar simulation applications.

The design goal for the PSS system is to simulate a realistic patient population. Associated with each patient is a therapeutic medication history consisting of a series of prescriptions to be filled. Several of the patients are subject to deliberately inappropriate medication levels or potential drug interactions. The system has the ability to generate a specified number of prescriptions based on one or more key variables, including the therapeutic class of drug, specific patient characteristics, drugs for which special handling procedures are required, or subsequent refills. The system also provides an answer key for the use of instructional personnel. The database design is a simple one, consisting of three levels of data (Figure 1): patient data, prescription data, and grading information. The simplified definition of the database FORMULARY (the framework upon which the DBMS organizes the data) is shown in Figure 2. KEY elements are logically accessible when retrieving data from or making updates to the database, and these form the basis for the selection of prescription characteristics for classroom use. As mentioned above, the database approach allows complete flexibility with respect to the addition of patients to the simulated population and to the number of drugs associated with each patient. With the population described and entered into the system, prescription generation is accomplished by randomly selecting a subset of the population having the desirable prescription or disease characteristics. The appropriate prescriptions are then formatted and printed. The system has the advantage that the chosen drug is always associated with a patient. This reflects the way prescriptions are presented to practicing pharmacists since all real prescriptions are indeed linked to real patients. Most importantly, a realistic patient medication profile is developed from when the student first encounters the patient until the end of the term. Moreover, the possibility of producing inappropriate patient-drug combinations is available as specifically desired by the instructor.

The Prescription Simulation System, as currently defined, is based on the logic shown in Figure 1, containing the data listed in Figure 2. Access to the simulated population is controlled by a series of COBOL programs that update, edit or retrieve data based on one or more of several parameters. The retrieval routines also perform the prescription generation function. The access programs may run either interactively or in batch mode depending on the function performed, although the prescriptions are presently generated only in batch mode and written to mass storage. This is due to the relatively longer processing times involved in prescription generation as well as to the desirability of printing the output on 8 1/2 x 11 paper. This use of COBOL interface programs has become the standard mode of database access in our hands, for it simultaneously provides a non-technical user access language, improved database security, and assures greater database integrity. It should be stressed that the interface programs are not file-oriented but logical entry-oriented

[2] MRI Systems Corporation, P.O. Box 9968, Austin Texas 78766.

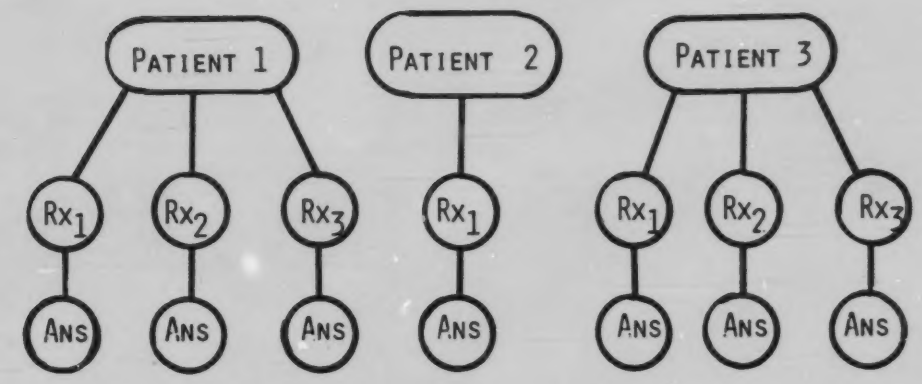

Figure 1. Logical Organization of the FORMULARY Database

```
100*  Patient name (key name x(30))
110*  Street address (non-key name x(30))
120*  CITY STATE (non-key name x(30))
130*  Birthdate (non-key date)
140*  Sort name (key name x(30))
150*  Patient characteristics (key integer 9(6))

200*  Drugs (RG)
      210*  Trade name (key name x(30) in 200)
      220*  Generic Name (key name x(30) in 200)
      230*  Control number (key name xxx in 200)
      240*  Therapeutic use (key name x(20) in 200)
      250*  Manufacturer (non-key name x(30) in 200)
      260*  Physician (non-key name x(15) in 200)
      270*  DEA number (non-key name x(9) in 200)
      280*  Refills (key name x in 200)
      290*  RX number (key number 9(6) in 200)
      300*  Amt dispensed (non-key name x(6) in 200)
      310*  SIG (non-key text x(40) in 200)
      320*  Drug Contraindications (key number 9(6) in 200)

      400*  Answers (RG in 200)
            410*  Answer text (non-key text x(70 in 400)
```

Figure 2. Simplified Database Definition for the FORMULARY Database (see text).

While the database organization and logic are totally transparent to the user, the COBOL access programs serve to create and process System 2000 natural language commands through the DBMS which then retrieves the desired data and presents them in informational form.

Each generated prescription falls into one of ten therapeutic classes adapted from the American Society of Hospital Pharmacists classification.[3] Prescriptions may or may not be

[3]American Hospital Formulary Service, published by the American Society of Hospital Pharmacists, Washington, D.C.

controlled substances and may be present by trade names or generic names, Non-key data associated with selected prescriptions (patient address, physician data, etc.) are retrieved simultaneously to produce complete prescriptions. In actual operation, the instructor creates a small specification file, either on cards or preferably on mass storage, which serves as input to PSS. A typical file is shown below, the resulting output for which is shown in the Appendix. The file contains a title for the prescription series, a date specification in MMDDYY format, a designator for the

```
A Dispensing Summer 1979

1  080279 M005 T

2  Analgesic

2  Cardiac

2  Autonomic
```

presence or absence of controlled substances (M="mixed"), the number of prescriptions desired (5), and a "T" or "G" for trade or generic names. On the succeeding lines the therapeutic class specifications are entered. When processed, this specifications file generates the set of prescriptions and corresponding help key listed in the Appendix. The instructor then separates the prescriptions and assigns them to students upon arrival in the laboratory. We have found that the accompanying answer key has proven to be of value to the laboratory instructors, helping them to provide positive guidance to students as laboratory exercises are being performed.

In light of the above advantages over manual or other automated approaches, the increased overhead associated with the DBMS seems well justified. The costs of operation include fixed costs of $1.50/hour in terminal connection charges, $0.02/page of printer output, and $2.00/academic quarter in magnetic tape storage charges. Variable costs of operation, based mainly on CPU time and mass storage charges, are naturally dependent on the size of the database and on the number of prescriptions requested. Thus, they are somewhat difficult to estimate. In preliminary tests the generation of 30 prescriptions in four therapeutic categories from a database containing 80 patients consumes about $3.00 in computing resources for a cost of about $0.10/prescription. Not included in this figure is the cost of instructor time or the costs associated with creation of the FORMULARY database or installation of the PSS programs. Also not included is the substantial cost (ca. $100,000) of System 2000 itself. Invariably a large system such as this will be purchased by an institution for many data processing uses other than the one discussed here, and in this light the system becomes more cost effective. The variable costs cited above will rise as the size of the patient population increases, but the rise will be an arithmetic one, not a geometric one since the level of sorting for retrieval of prescription data doesn't change within the database.

The Prescription Simulation System has performed very well to date, providing everything asked of it at this stage of development. Several additional features are currently being added to the system to improve usefulness and flexibility. Additional retrieval keys are being built into PSS software to utilize other data elements in the database. Included in this effort is the goal of prescription selection based on patient disease states as well as on drug therapeutic class, selection based on specific potential drug interactions, and the interactive retrieval of individual patient records or prescription records instead of random generation. This latter capability will be especially useful to the instructor wishing to compose a specific set of tasks for a quiz or examination. Also being studied is the implementation of online prescription generation capability in the dispensing laboratory. This feature would allow both a self-paced laboratory environment and voluntary practice for students with little or no additional strain on the instructional resources. The characteristics necessary to implement all of the above features are presently available in the FORMULARY database, and the additions will be accomplished by the creation or modifications of the PSS interface software. Once again, the described database approach provides a convenient means of growth and modification with little or no disruption of the existing system.

In summary, efforts have demonstrated another viable application of a state-of-the-art database management system to the instructional environment. It differs from our earlier results by its use in simulation rather than classical management. To our knowledge, no such application of a DBMS has been reported to date. In the narrow view, the Prescription Simulation System offers instructors of dispensing laboratories a useful and flexible teaching aid that can provide each student with learning material more meaningful than was heretofore possible, one that produces a substantial saving of time in material preparation. In the long view, we believe that simulations of this type using a database approach are quite feasible and potentially useful in any area of education where a suitable body of material exists. A particularly fertile area for further work is the area of clinical education, in Pharmacy as well as in the other health sciences, for design strategies identical to those of PSS could be used for the delivery of numerous other patient

or laboratory simulations.

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APPENDIX I - SAMPLE PRESCRIPTIONS

CYNTHIA NEHRING
PO BOX 18
PLYMOUTH, MN.
BIRTHDATE: 04/19/1953

ACTIFED

DISP # 30

SIG: 1 TAB TID PRN COLD SYMPTOMS

E.E. EXHALL MD.
REFILL X 2 AE3759803

FRED ZIMMER
814 WEST 34TH STREET
CRYSTAL, MN
BIRTHDATE: 12/24/1933

PERCODAN

DISP # 12

SIG: 1 - II Q3-4HPRN PAIN

F.R. PLAQUE DDS
REFILL X 2 AP9753100

GLADYS ZIMMER
814 WEST 34TH STREET
CRYSTAL, MN
BIRTHDATE: 05/14/1935

HYDRODIURIL 25 MG

DISP # 100

SIG: TABS 1 DAILY IN AM

R.C. DIASTOLEE
REFILL X 4 AD5757567

HARRIETT ANDERSON
3245 WEST 14TH STREET
ST. PAUL, MN
BIRTHDATE: 11/22/1945

MOTRIN 400 MG

DISP # 80

SIG: 11 TABS QID ARTHRITIS

M.M. PATHOGY MD.
REFILL X 4 AP5342144

MARY WYMAN
3490 18TH STREET SO.
EGAN, MN.
BIRTHDATE: 09/30/1941

PHENERGAN EXP WITH CODEINE

DISP # 4 OZ

SIG: 1 - II TSP Q4H PRN COUGH

K.K. HACKING MD.
REFILL X 1 AK/211990

APPENDIX II - SAMPLE INSTRUCTOR GUIDES

CYNTHIA NEHRING ACTIFED

CAUTION MAY MAKE PATIENT DROWSY
--USE CAUTION WHEN DRIVING A CAR -- LABEL ON BOTTLE
DRY MOUTH, BLURRY VISION, CONSTIPATION POSSIBLE

FRED ZIMMER PERCODAN

--CAUTION FEDERAL LAW PROHIBITS TRANSFER -- LABEL
--DO NOT OPERATE AUTO OR MACHINER WHILE TAKING MEDICATION, DO NOT USE ALCOHOL -- ON BOTTLE

GLADYS ZIMMER HYDROCHLOROTHIAZIDE 25 MG

WHAT PATIENT FOR POSSIBLE SIGNS OF HYPOKALEMIA
--DRINK CITRUS FRUITS OR A BANANA A DAY -- ON BOTTLE

HARRIETT ANDERSON IBUPROFEN 400 MG

POSSIBLE SALT RETAINING CAPABILITIES FOR THOSE PATIENTS WITH POSSIBLE CHF
GASTRIC UPSET POSSIBLE, ESPECIALLY IF ON EMPTY STOMACH
ENCOURAGE TAKING WITH FOOD OR MILK
--TAKE WITH FOOD OR MILK -- ON BOTTLE

MARY WYMAN PHENERGAN EXP WITH CODEINE

--SHAKE WELL ON LABEL --
--CAUTION FEDERAL LAW PROHIBITS TRANSFER -- ON BOTTLE
--USE CAUTION WHEN DRIVING -- STICKER ON BOTTLE
MUST HAVE RED C-III ON PRESCRIPTION

DIMENSIONS OF A SCORING SYSTEM FOR EVALUATION OF CLINICAL SIMULATIONS

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ABSTRACT: This paper describes an evaluation system that encompasses the variables of score, cost and time, and further discriminates between critical and routine decisions in computerized simulations. The evaluation format includes a scoring continuum ranging from life-threatening mistakes to essential positive steps, and has been shown to reliably differentiate successful from unsuccessful performance. When applied to computerized dental simulations, this scoring methodology shows that the ability to make routine decisions is not significantly enhanced by experience with the simulations. When only critical decisions are considered, however, the impact of exposure to sequences of simulations is more pronounced. In addition, review of individual decision pathways indicates a tendency toward less erratic, more competent individual performance over sequences of simulated patient cases. Additional work includes collection of further data on effects of simulated decision making and the impact of longer sequences of simulations.

Evaluation of impact upon users is a significant component of any program employing computerized simulations. Thus, scoring systems and the performance of individual learners assume an important role. Issues and procedures for scoring clinical simulations in the health sciences are discussed in this paper. In comparing data for successful and unsuccessful solutions based on differential characteristics of diagnostic and treatment-oriented simulations, the concept of critical decisions evolves as an important factor in evaluating judgment and decision-making processes.

Scoring

The problem of scoring decisions within simulations is a complex one, requiring judgments regarding content, timing, and sequence of possible alternatives. A significant limitation of early scoring systems was an inflexibility which did not take account of the time, cost, or availability of various procedures and decisions employed by the user (Friedman, 1973), resulting in questionable utility for such simulations in improvement of professional decision making. The simulations developed at the University of Nebraska (Lipson, Keith, Jones, 1979) include scoring values for simulated patient time and costs as well as points. These are recorded for each procedure in order to establish decision-making contingencies that are as realistic as possible.

There is not a "correct" way to score a simulation (Galofre, Note 1); rather, it is important that criteria be consistently applied and that scoring results reflect simulated patient outcomes in a reasonable way. Criteria employed in the present research in dental simulations were adapted from previous work by McGuire, Solomon & Bashook (1976).

Points

Assignment of point scores to individual decisions is primarily a function of author judgment, based on a set of standard scoring criteria (Table 1) and supported by experienced dental consultants. These criteria define a continuum of decisions ranging from absolutely essential (+4) to life-threatening (-4). The score assigned to any given procedure or activity may change within a simulation depending upon previous diagnostic tests, concurrent treatments, or other

variables which affect the current context of the problem.

Time and Cost

Two dimensions of clinical decision making that are significant to both the patient and to the decision-making process are the time and cost required by various courses of action. This is true not only as a matter of convenience and cost benefit, but also as a matter of clinical urgency when delay or indecision may endanger a patient's well-being. In the dental simulations, time and cost values are calculated to approximate local community standards.

Goodends and Badends

In the programming of the dental simulations, the term "badend" typically designates the program unit at which the user arrives subsequent to an irreparable mistake. This may occur for a variety of reasons, including life-threatening treatment decisions or mismanagement which sends the patient off to seek another dentist. The common feature is the inability of the user to continue appropriate care of the patient. As a matter of semantic convention, the term "goodend" has been adopted to describe any effective or acceptable solution to a simulation. Goodends may include appropriate diagnosis and referral, effective treatment selection, or an appropriate decision to simply monitor a patient's condition. Each problem typically has more than one possible goodend.

Critical Decisions

Table 1 shows that some routine, generally accepted procedures may add (or detract) relatively little (i.e., ±1 or 2 points) in relation to a user's total score, although a large number of such decisions result in substantial point accumulations. Bligh (Note 2) has suggested that these decisions may constitute "noise" in the system, and that the true impact of using clinical simulations may be on performance at the level of the critical decisions (i.e., those scored ±3 or 4 in the present system). It seems reasonable to assume that "ordinary" or routine diagnostic and treatment activities may be carried out by individuals without reference to critical decision making--and that improved decision making is more likely to be reflected in the specific execution of those procedures which are critical to the solution of a particular problem. In order to examine this assumption, data involving point totals are reported in two ways: (a) total scores for all decisions and (b) total scores for critical decisions.

Face Validity

A scoring system is useful only if it represents user behavior and problem outcomes in an accurate manner. The system must discriminate between successful and unsuccessful outcomes, and must be weighted in such a way that minor mistakes do not negate substantially appropriate solutions, while the effects of single critical mistakes are not obscured by large numbers of appropriate but routine decisions.

Tables 2 and 3, respectively, present data on total scores and scores for critical decisions for "goodends" and "badends" in four Nebraska simulations. In all cases, for both total scores and critical scores, the mean scores for goodends are clearly and substantially greater than those of badends. In addition, the ranges of scores of the two groups are non-overlapping in almost every case. These findings lend face validity to the scoring procedures, showing that reliable discriminations are made between successful and unsuccessful outcomes.

Decision Patterns Based On Problem Characteristics

Approximately 30 computerized clinical simulations have been developed at Nebraska. Each presents a unique diagnostic and/or treatment problem, and each is classified according to its nature as a typical or unusual and an acute or chronic dental condition (Lipson, Keith, and Jones, 1979).

The four problems (Neb 03, 04, 06, 07) referenced in Tables 2 and 3 are representative examples of three types of simulations:

Neb 03 and Neb 04 are typical chronic dental problems, requiring diagnostic decisions, selection of a treatment area, and appropriate treatment or referral;

Neb 06 is an unusual acute pedodontic problem, requiring diagnosis and an extended period of monitoring without active therapeutic intervention; and

Neb 07 is an unusual acute condition (Ludwig's angina), life-threatening in nature, and requiring rapid diagnosis and referral.

In analyzing the success of users in these various types of problems, several measures are of interest. These include the number of steps (i.e., decisions) required to complete the problem, the number of steps completed prior to selecting a treatment (or referral) area, and

the time and cost to the patient.

Total Steps

In typical diagnostic-treatment problems (e.g., Neb 03 and 04), there is no appreciable difference in the total number of steps (decisions) to achieve goodends and/or badends (Table 4). This seems due to the fact that both successful and unsuccessful outcomes require a series of diagnostic and treatment steps, with the final outcome dependent upon treatment results. Thus, a successful decision pathway is not necessarily longer or shorter than an unsuccessful pathway.

The picture is somewhat different when total steps to completion are studied for a problem requiring extended monitoring (Neb 06). In this case (Table 4), unsuccessful users tend to terminate too early, whereas successful participants utilize more steps, continuing to wait and observe until the problem is resolved.

Finally, in the case of an acute life-threatening condition (Neb 07), unsuccessful participants tend to persist in attempting to provide treatment, while successful users arrive at a diagnosis and make an appropriate referral without delay (Table 4).

Selection of Treatment or Referral

Table 5 shows that the pattern of behavior found in analysis of total steps also holds for the number of decisions occurring before a treatment or referral decision is made. That is, for the typical chronic problems (Neb 03 and 04), goodends and badends are very similar; unsuccessful users attempt treatment too soon in a problem requiring monitoring (Neb 06), and wait too long to refer an acute life-threatening condition (Neb 07).

Patient Time and Cost

In typical chronic cases, successful solutions tend to consume more patient time and dollars than do unsuccessful pathways (Tables 6 and 7). This does not mean, of course, that the latter are more cost-effective, for the clinical problem remains unsolved in these cases. The failure to refrain from treating in the case requiring extended monitoring results in less patient time (Table 6) and higher patient costs (Table 7) for unsuccessful users. Their tendency to delay and to attempt treatment results not only in higher time and cost measures but in the death of the patient as well, in the simulation which presents a life-threatening condition (Tables 6 and 7).

Exposure to Simulations: Effect on Decision Making

A fundamental question for the current research project is: When computer simulations are employed as an educational medium, does decision making improve with experience in the simulations? Two possible types of analysis include: (a) study of the effects (upon scores) of place in a sequence of simulations, and (b) effects of experience with simulations upon individual performance, including time and cost to patient.

Place in Sequence

Due to differing length and difficulty of simulations, it is not possible to directly compare individual performance on one problem to that of a prior or subsequent simulation. It is possible however, to compute mean scores for a typical simulation that has been used by a number of individuals at various points in their individually assigned sequences (i.e., first, second, fifth, etc.). These data are presented for one such problem (Neb 03) in Tables 8-10. When all decisions are scored for all subjects (goodends and badends) in all places in sequence (1-9), there is virtually no correlation between mean score and place in sequence. When goodends alone are considered (Table 8), this correlation is positive, but non-significant. When only critical decisions are scored, a more definitive trend emerges. The positive correlation approaches significance when all subjects are considered (Table 9), and reaches statistical significance when only goodends are considered (Table 10). While these data represent an N of only 28, as additional data are collected, the trend suggests that the major impact (on scores) of the simulations is upon performance at the level of critical decisions.

Individual Performance

While total scores are important, it is also of interest to view individual pathways in relation to patient time or cost. These individual pathways show whether decision making is smooth or erratic; improving or deteriorating; and cost-effective or -ineffective throughout the simulation. Changes in quality of individual performance may also be observed from one simulation to the next. Two representative examples are shown in Figures 1a-1c and 2a-2c. In Figure 1, the first, fifth, and ninth (post-orientation) simulations of user number 101 are summarized. The solid line plots a cumulative record of the individual's score in relation to patient dollars and an ideal

solution (dashed line). It may be seen that the individual's first effort resulted in a badend, the fifth was much improved but erratic, and the ninth was a close approximation to the optimal. Figure 2 contains a similar series (first, second, and fifth simulations) for user number 130, showing a similar improvement in scoring and efficiency relative to the optimal solution.

Conclusion

The simulations and scoring procedures summarized here seem to meet criteria of flexibility, credibility, and acceptability to users. Experience with the simulations has produced quantitative and qualitative changes in the behavior of participants, particularly in the area of critical decisions. Analysis of the scoring system suggests that it has face validity, facilitating ready discrimination between successful and unsuccessful pathways and between critical and routine decisions.

The findings to date are leading to additional work, including collection of further data on the effects of simulated clinical decision making, the impact of longer sequences of simulations, and the problem of relating simulated experience to *in situ* decision making.

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TABLE 1

Scoring Criteria for Simulation Decisions

Score	Criteria
+4	Critical to successful treatment (absolutely essential to optimal solution)
+3	Very Important (essential to any satisfactory solution)
+2	Helpful to solution, but not essential
+1	Appropriate or accepted procedure, but of minimal assistance to solution
0	Neutral, Optional (unlikely to help at this time, but not costly or risky)
-1	Inappropriate at this stage of this problem
-2	Harmful or unjustifiably costly (not irreversible)
-3	Irreversible treatment mistake (not life-threatening)
-4	Critical to health of patient (life-threatening)

TABLE 2

Mean Scores: All Decisions

Simulation	Goodends	(N)	Badends	(N)
Neb 03	30.09	(22)	2.67	(6)
Neb 04	34.83	(24)	15.00	(4)
Neb 06	32.67	(12)	10.67	(3)
Neb 07	14.11	(19)	-2.50*	(2)

* Patients died.

TABLE 3

Mean Scores: Critical Decisions

Simulation	Goodends	(N)	Badends	(N)
Neb 03	23.45	(22)	2.50	(6)
Neb 04	9.29	(24)	-3.75	(4)
Neb 06	31.00	(12)	7.00	(3)
Neb 07	1.32	(19)	-20.50*	(2)

*Patients died.

TABLE 4

Total Steps in Problem (Mean)

Simulation	Goodends	(N)	Badends	(N)
Neb 03	50.09	(22)	44.17	(6)
Neb 04	63.00	(24)	63.25	(4)
Neb 06	33.08	(12)	17.67	(3)
Neb 07	25.00	(19)	45.50*	(2)

*Patients died.

TABLE 5

Mean Step at Which Treatment or Referral First Occurs

Simulation	Goodends	(N)	Badends	(N)
Neb 03	24.91	(22)	23.33	(6)
Neb 04	40.54	(24)	38.75	(4)
Neb 06	20.25	(12)	12.00	(3)
Neb 07	19.89	(19)	38.50*	(2)

*Patients died.

TABLE 6

Mean Patient Time in Minutes

Simulation	Goodends	(N)	Badends	(N)
Neb 03	152.27	(22)	134.83	(6)
Neb 04	285.46	(24)	168.75	(4)
Neb 06	144.08	(12)	85.00	(3)
Neb 07	63.74	(19)	80.00*	(2)

*Patients died.

TABLE 7

Mean Patient Cost in Dollars

Simulation	Goodends	(N)	Badends	(N)
Neb 03	128.34	(22)	77.17	(6)
Neb 04	194.44	(24)	114.38	(4)
Neb 06	46.92	(12)	60.33	(3)
Neb 07	31.53	(19)	55.50*	(2)

*Patients died.

TABLE 8

Rank-Difference Correlation between Mean Total Scores and Place in Sequence for Goodends (Neb 03)

Place	Mean Score
1	34.75
2	26.00
3	28.17
4	19.00
5	31.00
6	37.00
7	25.50
8	--
9	38.50

Rho = .262

TABLE 9

Rank-Difference Correlation between Mean Total Critical Scores and Place in Sequence for all Subjects (Neb 03)

Place	Mean Score (Critical Decisions)
1	16.83
2	19.33
3	21.14
4	17.00
5	21.50
6	8.00
7	27.00
8	--
9	27.50

Rho = .570

TABLE 10

Rank-Difference Correlation between Mean Total Critical Scores and Place in Sequence for Goodends (Neb 03)

Place	Mean Scores (Critical Decisions)
1	22.25
2	19.33
3	24.67
4	22.50
5	21.50
6	24.00
7	27.00
8	--
9	27.50

Rho = .714

$p < .05$

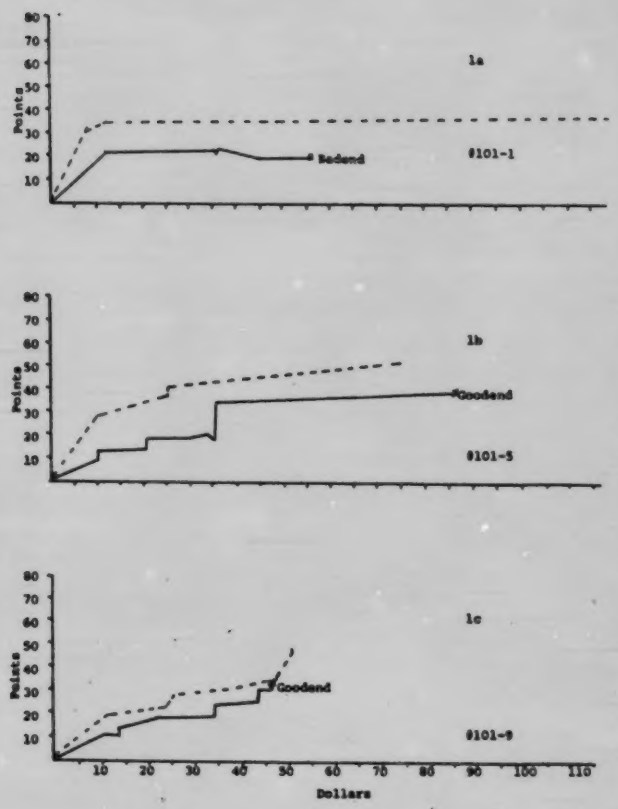

Figure 1. Individual cumulative records, user #101.

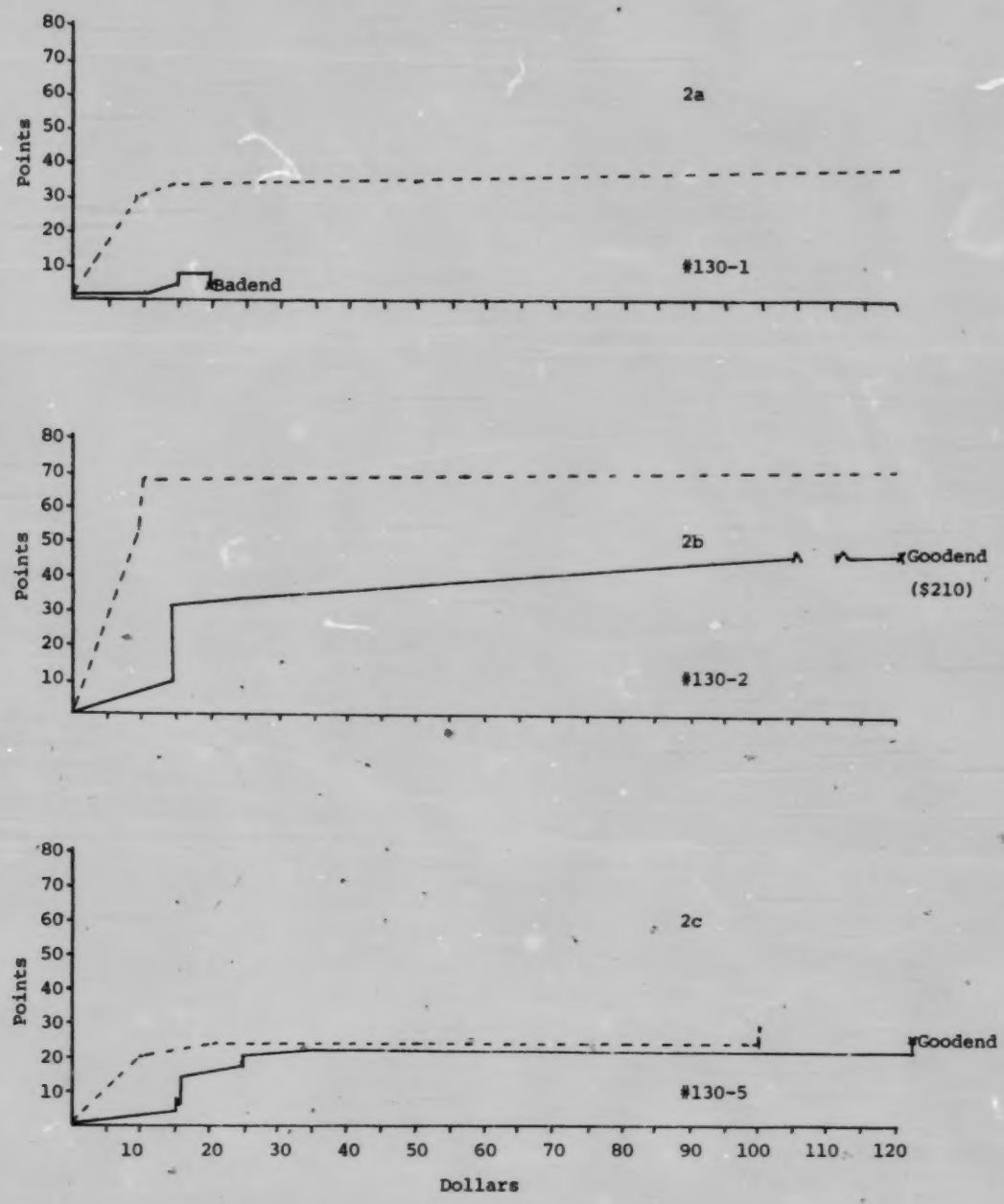

Figure 2. Individual cumulative records, user #130.

A PLATO SIMULATION FOR DEVELOPING AND ASSESSING CLINICAL COMPETENCE IN CHILDBIRTH MANAGEMENT

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ABSTRACT

The instructional culmination of the University of Connecticut Health Center's Intrapartum Fetal Monitoring Curriculum is a simulation of childbirth management. Using fetal monitoring charts and data drawn from actual labors, the simulation gives only those cues which correspond to the usual stimuli of the delivery room and gives the user the full array of options that a practicing obstetrician would expect to find in that environment. The simulation responds to the use of these options in a medically credible fashion so that clinical realism is maintained. A user's management of this simulated case generates a detailed record of the use of management options and the sequence of their use. This record is then compared to clinically acceptable standards. This comparison can, in turn, be used as a basis for assessing clinical competence and/or teaching proper management techniques. The present version of this simulation performs both functions by presenting the user with an evaluation of the management which is based on current obstetrical standards and by recommending remedial resources.

INTRODUCTION

In November of 1977 the University of Connecticut Medical School began a PLATO project in continuing medical education (CME) committed to developing six to eight hours of computer-based courseware in electronic intrapartum fetal monitoring and human genetics. The purpose of the project was to demonstrate the PLATO system's capabilities for CME. The outcome of this project was a nine to ten-hour PLATO curriculum entitled Intrapartum Fetal Monitoring and a three-hour PLATO sequence on hypertensive and diabetic disorders in pregnancy.

The fetal monitoring curriculum has been approved for CME credit by both the American College of Obstetricians and Gynecologists and the University of Connecticut School of Medicine for Category I credits toward the American Medical Association Physician Recognition Award. An application for accrediation by the American Nursing Association is also being made.

A part of the fetal monitoring curriculum is a PLATO simulation of childbirth management. This paper discusses the characteristics of the simulation and its place in the curriculum.

INTRAPARTUM FETAL MONITORING

The Intrapartum Fetal Monitoring curriculum was written by E. J. Call-Himwich, H. A. Himwich and L. W. Miller. Table 1 lists its instructional units for which the basic educational goals are:

1. Introduce students to the instrumentation of fetal monitoring (Lessons 3-8).
2. Develop skills needed for interpreting records obtained by these instruments (Lessons 9-11).
3. Give the student an opportunity to apply these skills in three PLATO simulations demanding various levels of clinical competence (Lessons 12 and 13).

A lesson introducing the student to the PLATO system and the curriculum (Lesson 1), and a diagnostic pretest which recommends lessons and portions of lessons in the curriculum based on the student's current knowledge (Lesson 2) are

also included. Lesson 14 is a glossary of fetal monitoring terms, easily and quickly accessible from any other lesson. With lesson 15, quiz items on fetal monitoring, the student may assess his own knowledge and compare it with others using the same item bank.

TABLE I

LESSON TITLES
INTRAPARTUM FETAL MONITORING

1) Guide to PLATO.
2) Pretest/Study Recommendations.
3) The Fetal Monitor.
4) Ultrasonic Fetal Heart Monitoring
5) Phonocardiography.
6) The Spiral Electrode.
7) The Tocodynamometer.
8) Using the Intrauterine Catheter in Fetal Monitoring.
9) Baseline Changes, Part I.
10) Baseline Changes, Part II.
11) Periodic Changes.
12) Practice Cases.
13) Childbirth Management.
14) Glossary.
15) Self-Assessment.

CHILDBIRTH MANAGEMENT SIMULATION OVERVIEW

The intent of the childbirth management simulation is to assist the development and evaluation of clinical competence by allowing the student to manage a simulated labor based on actual cases with a minumum of prompting. After giving the student the initial patient status (Figure 1), the simulation presents a sequence of reproductions of fetal monitoring charts (Figure 2). The upper portion of each chart is a plot of the fetal heart rate (FHR); the lower, a plot of the maternal uterine contractions. With each display, the student has the option of asking for information concerning the patient and/or taking any action that is deemed appropriate. Figure 3 shows what resources the student has for managing the labor. As the student manages the labor, a sequence of medically credible fetal monitoring plots are shown. The sequence any student sees is dependent upon the management options chosen. The simulation is thus capable of yielding outcomes which realistically reflect individual techniques of labor management. Throughout this management phase, the time and order of any important student action are stored for use in summarizing the case. After performing either a normal vaginal or cesarean delivery, the student receives the case management evaluation. During this last phase the student's actions are recalled and compared with currently accepted clinical practices.

FIGURE 1

CURRENT STATUS

MOTHER

AGE	:	27 years
GRAVIDA	:	1
PARA	:	0
PRENATAL COURSE	:	normal
GESTATION	:	40 weeks
BLOOD PRESSURE	:	96/68
PULSE	:	72 bpm
TEMPERATURE	:	97.8° F
RESPIRATION	:	18
POSITION	:	back

BABY

HEART RATE	:	150 bpm by auscultation
ESTIMATED WEIGHT	:	8 lbs.

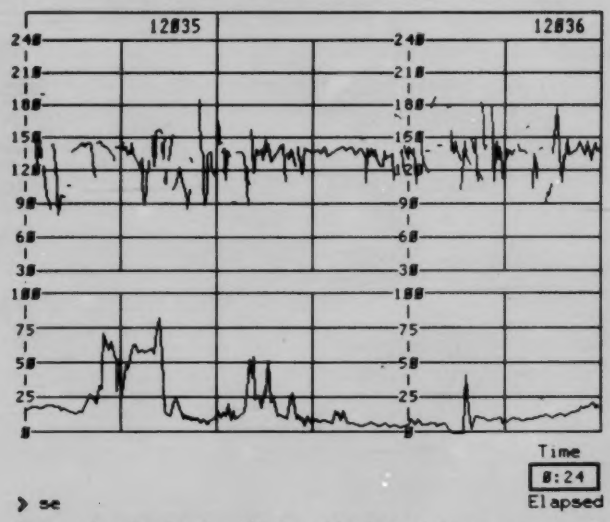
LABOR

MEMBRANES	:	ruptured 4.5 hours ago with fresh meconium stains
FHR MONITOR	:	ultrasound
UC MONITOR	:	tocodynomometer
OXYTOCIN	:	0.0 mu/min

Press NEXT to begin. HELP

FIGURE 2

THE STUDENT ORDERS ATTACHMENT OF SPIRAL ELECTRODE



> se

The scalp electrode will be attached right away.

NEXT

FIGURE 3

STUDENT OPTIONS

At anytime in the simulation, you will have access to the resources listed below. To obtain information or take an action, type in the corresponding letters. Don't bother to memorize these letters. They have been selected with an eye to easy recall and will be available via the HELP key at any time.

INFORMATION		ACTIONS	
		tl	= patient on left side
		tr	= patient on right side
		tb	= patient on back
fhr	= ausculated fhr	au	= adjust ultrasound
t	= time since rupture of membranes	at	= adjust tocodynamometer
		se	= attach scalp electrode
me	= status of meconium staining	ic	= insert pressure catheter
		fc	= flush catheter
lve	= data and time of last vaginal exam	pc	= palpate contractions
		ivf	= give intravenous fluids
fm	= estimated fetal mass	pit+	= increase oxytocin dose
vs	= maternal vital signs	pit-	= decrease oxytocin dose
p	= maternal position	ss	= perform scalp sample
c	= contraction strength	xp	= do x-ray pelvimetry
mon	= monitors being used	cp	= do clinical pelvimetry
pit	= oxytocin dosage	ve	= do vaginal exam
		o+/-	= give/stop oxygen
		ns	= do nasopharyngeal suction
		cs	= do cesarean section
		df	= deliver fetus

BACK to return to lesson NEXT to review key functions

Thus the simulation consists of three distinct phases:

1) Introduction to the protocols of the simulation and to the patient.
2) Management of the simulated case.
3) Evaluation of the outcome and the techniques used to achieve it.

Although the simulation may be used independently, it is intended as the logical culmination of the fetal monitoring curriculum. Skills needed to recognize the quality of information being obtained by fetal monitoring instrumentation are covered in Lessons 3-8 (Table 1). The student learns to identify clinically critical FHR patterns that may occur during the simulation in Lessons 9-11 (Table 1). Finally, a clinically acceptable sequence of management techniques of dealing with these patterns is taught in Lesson 12, "Practice Cases," which also gives the student intensive practice in evaluating fetal monitoring charts. Whereas "Practice Cases" actively solicits interaction by means of direct questioning, the student receives few cues in the simulation. To achieve the lesson objectives, i.e., to obtain the best possible outcome, the student must gather information and make management decisions using skills similar to those needed in the actual clinical setting. Because instructive feedback comes only after the student has completed the lesson objective, the management simulation stands in the same relation to the fetal monitoring curriculum as the exercise of determining a chemical unknown does to a qualitative chemistry course.

MANAGEMENT PHASE

The Database. The simulation contains six hours of labor records stored in six-minute segments. The fetal monitor plot in Figure 2 shows the graphic component of one such segment. In addition to a plot, 25 variables with information concerning the maternal vital signs, fetal metabolism, and progress of the labor are associated with each six-minute segment. Although these variables may be, and occasionally are, conditioned by the student's path, most of them are drawn directly from the nurses' log of the labor.

Student Routing. After being briefed on the patient's condition (Figure 1), each student begins the management phase with the same six-minute segment. What a student sees after the initial segment is conditioned by the management options used. The manner in which the fetal heart rate (FHR) monitor is handled illustrates this conditioning. As the labor begins, the FHR is being monitored with an ultrasound transducer which is applied externally to the maternal abdomen. The first plot is one characteristic of this method of FHR monitoring. At this time the student has the option of attaching a spiral electrode to the fetal scalp to improve the FHR plot (Figure 3). If the student opts to attach the spiral electrode, the next plot he sees is one from the same labor during which it was actually being attached. If this management option is not taken, the student sees another plot that was obtained using an ultrasound FHR monitor and once again has the option of attaching the spiral electrode. Thus, the sequence of plots seen by the student, as well as the actual outcome, is determined by the management of the case.

Each management option is always available to the student. Success of execution, however, may depend upon when in the sequence of plots the option is requested. For example, the student can deliver the infant only when the labor has progressed to the point that vaginal dilation is sufficient. If an attempt to deliver is made before this time, the student is told that a vaginal delivery cannot be performed until dilation reaches 10 cm. On the other hand, a cesarean section, which does not depend on such physiologic constraints, may be performed at any time. Due to limitations of design or equipment, many simulations cue the student by varying the available options as the student moves from place to place. While this variation may enhance some simulations, it would detract from the effectiveness of a simulation aimed at teaching and assessing clinical competence.

FIGURE 4
INITIAL PAGE OF MANAGEMENT EVALUATION

```
CASE SUMMARY

The infant you delivered had an Apgar score of
2 at 1 minute and 8 at 5 minutes.
You will now be taken through a discussion of your
management of this case. In turn, management of each
of the following will be discussed
      1. fetal monitors
      2. primary uterine inertia
      3. late decelerations
      4. meconium stained amniotic fluids.
Press NEXT to begin this discussion.
NEXT   DATA   HELP   NOTES   REPLOT
```

THE EVALUATION PHASE

By the time an infant has been delivered, all data needed to evaluate the management of the case have been stored. What sequence of plots the student has seen is known as well as what options have been used and when a given option was executed in relation to the sequence. This information is then used to present the student with an evaluation of the clinically important aspects of the case:

1) Using fetal heart rate and uterine contraction monitors to obtain optimal information.
2) Primary uterine inertia.
3) Overstimulation with oxytocin.
4) Late decelerations.
5) Meconium staining.

Figure 4 shows the first display seen by a student who has delivered a healthy infant without overstimulating the mother. (Note that the third item on the above list does not appear in this display.)

Figure 5 is a typical page from the evaluation which notes that the student attached the spiral electrode (Figure 2) but did not insert an intrauterine pressure catheter to improve the record of the force and frequency of uterine contractions.

FIGURE 5
PRINT OF EVALUATION OF USE OF FETAL AND UTERINE CONTRACTION MONITORS

```
CASE SUMMARY

Management of Monitors

You have correctly recognized the inferior record of
changes in the fetal heart rate and have acted properly
to obtain better information. You did not, however,
act similarly to improve the record of the uterine
contractions by requesting insertion of the internal
pressure catheter.

While it was not possible to foresee whether you would
have given instructions to evaluate this patient's
contractions more appropriately, the chief resident
intervened in this case after what was felt to be a
reasonable time for the problem to be recognized and
corrected.

BACK   NEXT   DATA   HELP   NOTES   REPLOT
```

As each aspect of the case is reviewed, the student's record is checked for use of the appropriate management options. Where they have been carried out, congratulatory feedback is given; where they have not, the divergence from accepted practice is noted along with the clinical grounds for such practice.

Finally, where appropriate, the evaluation recommends other portions of the fetal monitoring curriculum for remediation.

TEACHING CLINICAL PROBLEM-SOLVING:

A PRELUDE TO SIMULATED CHILDBIRTH MANAGEMENT

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ABSTRACT

During 1978 and part of 1979, the Computer-Based Education Project (CBE) at the University of Connecticut Health Center designed and developed a PLATO-based curriculum in electronic fetal heart monitoring during labor and delivery. The course culminates in a clinical simulation in which the student manages a patient in labor.

This paper describes a "prelude" to the final childbirth management simulation. This "prelude" is an attempt to teach the problem-solving process itself in an area which often requires rapid, subjective assessments.

INTRODUCTION

How do you teach clinical problem-solving in an area that often requires rapid, subjective assessments? How do you teach students to apply an analytic decision making process to a dynamic situation in which decisions are constantly reevaluated? For the last two years, the CBE project at the University of Connecticut (UConn) Health Center has been developing and refining what we hope are some solutions to these problems.

In 1977, UConn Health Center was awarded a grant from the Control Data Corporation to research and develop a PLATO based Continuing Medical Education (CME) course in electronic fetal heart rate (FHR) monitoring during labor and delivery. Over the course of a year, we developed an extensive curriculum which we believe gives the student a thorough foundation in both the common types of electronic instrumentation, and in pattern analysis. The course culminates in a clinical simulation in which the student manages (unaided) a patient in labor. We felt, however, that there needed to be a bridge between the didactic, content material and the final simulation. Therefore, we developed a prelude to the simulation in which, by going through the litany of questions (s)he must repeatedly ask, the student can "practice" the problem-solving process itself. The purpose of this paper is to describe this prelude of "Practice Cases" and relate student reaction thus far.

TALKING TO CLINICIANS (AN ENCOURAGING WORD)

In breaking down the process of clinical thinking, you naturally need to consult at length with a clinician. Lest you are entertaining the idea that this sounds like the easy part, I would like to make a few observations on the art of picking someone's brain when one of you seems to be speaking Swahili while the other is responding in tongues. Dr. Lawrence Miller, the obstetrician with whom we collaborated, was extremely enthusiastic about working on this project. He was also extremely dubious about most of our development procedures. Not only did we have a linguistic problem, we had a conceptual problem as well. Since he had no experience with how things like task analyses, flow charts and objectives bloom into lessons, he concluded these techniques were irrelevant—a waste of time. Conversations turned into defenses of even the most basic design techniques.

Me: I want to do what is called a task analysis. That just means sifting out the steps your mind goes through when you're looking at an FHR plot trying to decide what to do.

Miller: Well, what does that have to do with the fetal monitoring stuff?

Me: By pinpointing the steps that your mind works through, we will know more about what specifically the student has to know and be able to do to analyze a tracing.

Miller: (with a frustrated flourish of hands) But I don't go through any 'steps' in my mind, so this so called task analysis thing has nothing to do with anything.

Me: (wondering why he can't just take my word and stop wasting time) But even if you're not aware of it, your mind must be methodically processing through a lot of checkoff points. A task analysis will simply tell us what those are.

Miller: (wondering why I can't just take his word and stop wasting time) No, it doesn't. I just more or less 'react' to the tracing. There isn't any process at all.

It was at this point that we reached our first singleness of thought—and that thought was the realization that we had a bigger problem than just problem-solving.

After all manner of disagreement, disarrayment, disillusionment, and disavowal, we finally began to understand what each was talking about. Dr. Miller now tosses terms like "formative evaluation" with devil-may-care abandon (though he still says he doesn't quite see how those lists and charts are transformed into lessons). While a certain amount of ambiguity and debate is to be expected, we could have avoided much of our initial misunderstanding and frustration. Our first mistake was in using terminology which sounded so foreign that it made the ideas themselves sound foreign too. Our second mistake was in allowing so much time to be spent in freewheeling debates on technique. When we finally stopped explaining ourselves and started simply putting up preliminary "running starts" at the material, Dr. Miller began to understand the long-buried, multilayered process his mind went through when he looked at a tracing. Now that the material is developed, of course, we are able to essentially provide him with a specific list of questions and plug his answers into a driver. It was not until we gave him something concrete to respond to, however, that he could give us anything concrete in return.

PRACTICE CASES

At the start of development, our primary interest was in giving the student experience with as many different FHR patterns as was possible. As we worked through a number of labor records, however, a common pattern began to emerge and we concluded that if we could teach the student the step-by-step questioning process, (s)he would be well equipped to deal with patterns (s)he had never seen before.

By using actual FHR tracings and having Dr. Miller talk through each tracing, we concluded that there were four overall questions the clinician must ask him/herself for every panel of FHR plot as it comes out of the monitor. Each general question is, of course, comprised of a subset of questions, but the overall questions are:

1. What does this tracing look like?
2. What are the possible causes for this pattern AT THIS POINT IN THE LABOR?
3. Is this fetus showing only signs of STRESS or also DISTRESS?
4. What should I do?

Therefore, we constructed the lesson so that the student is repeatedly answering these questions throughout. Since it would be impractical to ask for such constant commentary for an entire case, the student sees only a sampling of tracings from various cases which represent commonly seen FHR patterns. A case in this context consists of only a segment of the entire labor record.

On entering a case, the student is first given pertinent background information on the progress of the labor up to the point at which the student entered the case. (S)he is not, however, given information on the current status of either the mother or the fetus. The student must determine this information. After the preliminary information is given, the student is shown the first panel of FHR tracing. (S)he is then asked (one at a time) the series of questions necessary to simply describe the tracing:

What is the baseline fetal heart rate?
How would you assess FHR variability?
What is the contraction frequency?
Are the contractions too frequent?
Are there any periodic changes?

If the student has stated that there are periodic changes when, in fact, there are not, (s)he is asked to touch a place on the tracing which (s)he regards as a periodic change. The student then is quizzed about the nature of the alleged periodic change, and about supporting evidence. Finally the student is lead to a summary of why, in fact, the indicated portion is not a periodic change.

If the student stated that there were periodic changes and, in fact, there are, (s)he is asked to state what kind they are and to give (one at a time with feedback provided for each) the criteria which lead to the label (s)he has applied. For example, if the student has labeled the FHR pattern "late decelerations," (s)he must then supply the three distinct characteristics of late deceleration patterns and how they apply to the tracing.

After the student has given justification for his/her conclusions, (s)he is then asked, "What are the possible explanations for this FHR pattern at this time?" Each explanation must be entered separately so that it can be given specific feedback. There are usually five or so possible explanations for a given pattern, some of which should be thought of in order. For example, if the student offers "fetal distress" as the first explanation for a given pattern, feedback would be, "Fetal distress is a possibility, but there are a number of other explanations you should consider first. For instance, what signal might you be picking up OTHER than the fetal heart rate?" Help is available in the form of a single hint for each remaining factor the student has failed to include. For example, the first time the student seeks help, (s)he might see the hint, "What medication has the mother recently received?" while the second time (s)he seeks help, the hint may say, "How has the fetal head recently been manipulated?"

When the series of explanations is complete, the student is asked, "What (if any) action would you take?" Once again, there are usually four or five actions the student must specify one at a time. Feedback is given for each action specified. For example, if the student answers with "give the mother oxygen," feedback is, "Good. Even a small increase in maternal oxygen intake can produce a significant increase in fetal oxygenation. What OTHER action would you take?" If the student attempts to recommend an action which is premature or which should have first been preceded by another action, (s)he is told so. For example, if (s)he tries to give intravenous fluids before checking the maternal blood pressure, the feedback is, "Before loading fluids, how can you determine whether or not the mother is hypotensive?" Help is available in the form of single hints such as, "How can you relieve possible cord compression?" or "How can you get more specific data on the extent of fetal acidosis?" If the student has failed to specify certain critical actions, (s)he is further prompted. For example, in one case, the student should have at least alerted the staff to prepare for Cesarean section. If (s)he fails to do so, (s)he is asked, "In the hospital in which you work, how many minutes pass between the time you alert the staff to prepare for a section and the time preparations are ready?" If the student replies, "Eighteen minutes," the computer responds, "Then if you alerted the staff right now, this FHR bradycardia would have persisted for 24 minutes before you could perform a section. Do you think the staff should be alerted?" Later in the program, the student is asked, "Is a section still appropriate?" When this entire line of questionning is completed for that piece of FHR tracing, the student sees the next piece of tracing which follows chronologically. Once again, the student must describe the tracing, give possible explanations, and specify appropriate actions.

Throughout each case, the student is also asked fairly subjective questions which usually have no single correct answer. The point is not so much the answers, as the questions themselves. While the answer to a question like, "What is this fetus telling you about its oxygenation?" or "Is this fetus currently undergoing distress?" might vary from clinician to clinican, the point of asking is to remind the student that these are the questions that should be on his/her mind.

At the end of a case, the student is told how the clinician attending the case had acted and what the result had been. The appropriateness of the clinician's actions are then discussed.

CONCLUSION

To date, we have run nearly one hundred obstetricians, nurses, and medical students through the fetal monitoring course. Data on lesson effectiveness is still largely anecdotal. Students at all levels of expertise have stated that the Practice Cases seem to help them remove most of the subjective guesswork heretofore associated with much of fetal monitoring analysis. One of our most heartening bits of feedback came from a pediatrician after he had gone through the final simulation. He commented, "You know, when I saw that first piece of tracing, I thought, 'Oh, my god. Now what do I do? I'll kill this kid for sure.' But then I remembered all those questions you are supposed to be thinking about and I started going through them in my head, and pretty soon I felt a lot calmer and thought I could see what was going on in the case." Sounds suspiciously made to order, I know. It surprised even us.

In the future, we hope to experiment more extensively with both the Practice Cases and the final simulation to

determine whether the two together are useful tools for improving clinical competence.

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Votaw, R.G. and Miller L. "Intrapartum Fetal Monitoring: A Computer-Based Approach to Development and Assessment of Clinical Competence," IEEE Proceedings, 1980.

THE UNIVERSITY OF AKRON'S COMPUTER BASED EDUCATION NETWORK:

A REPORT ON ACTIVITIES AND RESULTS OF A FIVE YEAR STUDY

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ABSTRACT

The University of Akron is physically located within the center of the city of Akron, Ohio, and has acknowledged that it has a responsibility to act as a resource for the entire community. One way in which the University is attempting to meet the community's needs is through its Computer Based Education Network.

The University maintains an extensive Computer Based Education network which serves the entire University (24,000 students) and a large segment of the surrounding community. The University's CBE Center is well known for its courseware development and network. This paper will address the University's CBE work with the elementary and secondary schools. The network's lines reach out over Summit, Portage, Cuyahoga, Medina, Richland, and Wayne counties offering courseware in the following categories:

Accounting	Guidance
Business	Mathematics
Chemistry	Medicine
Computer Programming	Metrics
Education	Psychology
English	Reading
Foreign Languages	Statistics

The University's commitment to CBE began in 1972 with five typewriter-like terminals in Simmons Hall. Since then the operation has expanded to 80 cathode ray tube terminals which involve many departments at the University as well as the recently established Northeast Ohio Universities College of Medicine. What follows is a county by county description of CBE activities and outcomes that have taken place over the past five years.

SUMMIT COUNTY

WOODRIDGE SCHOOL DISTRICT

The beginning of public school involvement in The University of Akron's CBE network is rooted in the tiny Woodridge School District which sits in the heart of the Cuyahoga River Valley. The project, which began in 1974, produced a three-year study which was completed in 1977. The results were so impressive that the Woodridge project served as a model for the entire CBE network. It, also, served to extend the network to new users because of the publicity produced by the local media's interest in the program. Local television and newspapers as well as area educators studied the program in depth.

The Woodridge curriculum incorporated CBE as an instructional support system into the Remedial Reading Program. The original pilot program began at the Junior High in 1974. Another CBE learning station was established at the intermediate level in a learning resource center in 1975. An average of 200 students per year were served by the two CBE learning stations. A reading specialist worked at each level of the instructional program. Students with the most serious reading deficiencies were given priority as users, and ten-minute CBE lessons were taken on a daily basis. The yearly patterns of achievement since 1974 have stabilized and matched or exceeded those results. The 1978-79 year's results were higher in achievement than in previous years. A summary of the results from the original Woodridge Study follows.

Results of the Woodridge Study

The Woodridge outcomes show significant performance improvements and other important positive spinoffs. The achievement results were as follows: In the 1973-74 school year the CBE treatment was used from January to June on 7th and 8th grade students.

The CBE treatment groups averaged 2 months growth for every month in the program; the non-CBE treatment group averaged 1.4 months growth for every month in the program. During the 1974-75 school year, the CBE treatment was used from September to June on 7th and 8th grade students. The CBE treatment group averaged three months growth for every month in the program, and the non-CBE treatment group averaged two months growth for every month in the program.

During the 1975-76 school year, the CBE treatment was used from September to June on 7th and 8th grade students. The CBE treatment group averaged three months growth for every month in the program, and the non-CBE treatment group averaged two months growth for every month in the program.

During the 1975-76 school year the CBE treatment was used from September to June on 7th and 8th grade students and from January to June on 5th and 6th grade students. The CBE treatment group averaged two months growth for every month in the program, and the non-CBE treatment group averaged 1.5 months growth for every month in the program. These results indicate that CBE drill-and-practice in reading adds significantly to reading achievement growth and that the effects replicate over a variety of grade levels. Hirschbuhl, (1977)

Other Outcomes of the Woodridge CBE Experience

The Woodridge Schools have experienced and observed the following:

1. The Director of Guidance, whose office is located at the High School, has seen a marked improvement in the incoming freshmen, particularly in self-image, discipline, and attitude.

2. Dozens of letters have been written by parents praising the Reading Program and offering support.

3. The Language Arts Department at the Junior High School has been actively involved in supporting the Reading Program and helping to build it.

4. Newspapers and T.V. stations have covered the program.

5. Visitors from surrounding school districts, other states, and other countries have found their way to the tiny Woodridge School District.

6. An awareness of Computer Literacy has developed, and field trips are made to computer centers and The University of Akron's CBE Center.

7. A group of youngsters not enrolled in the program have developed computer skills, learned computer languages, and have displayed hidden talents.

8. A strong association among professors, teachers, and students has developed through the University and School CBE alliance.

9. A CBE Math Program was developed and initiated at Woodridge Junior High School.

10. Teachers have strongly supported something they feel is needed and have given extra time and study freely.

Conclusions of the Woodridge CBE Experience

1. CBE is an effective instructional tool which can be effectively used in remediation of skills in the classroom.

2. CBE can serve as a learning enrichment tool as well as a tutorial learning tool.

3. Students who were actually suffering learning loss can improve to above average gains in learning if concentration and attention is provided.

4. CBE helps to erase the stigma attached to special reading programs. Both advanced and remedial students alike flock to the Reading Center, working together on their studies and asking to be placed on CBE.

5. An Open Door Policy between superintendents and teachers can lead to building very worthwhile instructional programs for children.

6. As other studies have pointed out and as Title I has stressed, the greater the coverage of students by one teacher, the less growth for those who are seriously deficient in basic skills, i.e. small groups are beneficial to learning.

7. As other studies have shown, students who have not learned through traditional methods will benefit from changed methods and new strategies.

8. Students respond better to regularity in conditions, i.e. daily sessions, meetings, knowing what is expected; especially students in need of help. (This, too, is supported by studies.)

NOTE: Most of the above conclusions have been replicated in all other A.U. CBE School learning stations.

Despite the inclusion of the Woodridge School District into a newly established national park which resulted in declining enrollment due to the massive purchase of acreage by the Park Authority, the CBE Project remains intact as a part of their Remedial Reading Program. (An Apple II has been added for programming at the secondary level.) At this point in time, the project is five years old, and the original terminal at the Junior High has been placed in the permanent equipment category of the budget. HUMRO designated Woodridge an exemplary computing project for children. Hirschbuhl (1977)

THE AKRON PUBLIC SCHOOLS

The Akron City Schools have established what is now becoming a growing number of CBE learning stations in various subject areas.

Seiberling

Seiberling Elementary School, which houses 900 students, has programs set up conversely for learning disabled students and the gifted. Their program began with one CBE learning station for learning disabled students in 1976. Last fall, a new station was added for gifted students. The Seiberling principal has no assistants or reading specialists in her school, and she views CBE as an inherent and vital instructional support system.

Results of the Seiberling Study

Two years of statistical data have been collected concerning the achievement levels of the Seiberling CBE students using the program. The students involved have been diagnosed as having low-level reading skills, i.e. one or more years below grade level.

The results were as follows: The 1977-78 group and the 1978-79 group were pretested in the areas of vocabulary and comprehension using the California Achievement Test at the beginning of the respective school years prior to any CBE experience. A second form of the same standardized test was administered to the groups at the end of the school years. The results were reported in terms of grade level equivalents. During the 1977-78 school year, the 5th grade CBE group showed a gain of 1.43 grade levels from pretest to post-test, and the 6th grade group gained 1.63 grade levels. Hirschbuhl and Konet (1978)

The 1978-79 pre and post-tests resulted in scored indicating an average overall gain of 0.3 for the 5th grade group and 0.9 for the 6th grade group. There were several variables which could account for the inconsistencies from one year to the next including the method of selection of the students for CBE subjects in each of the groups. One major variable was the inclusion of mostly L.C. and EMR students into the 1978-79 program. The 1977-78 program concentrated on extreme reading deficiencies. Hirschbuhl and Myers (1979)

Analysis of questionnaire responses of the Seiberling participants indicated that "the acceptance of the terminal by staff members relies heavily on the acceptance and enthusiasm of the principal. The staff attitude in turn affects the student attitude. Although student attitude toward the terminal is affected by his environment, reading achievement is not significantly affected by staff attitude, but is enhanced significantly by the utilization of CBE as part of the learning process." Hirschbuhl and Konet (1978)

Jackson

Two years ago (1978-79 school year), an exciting adventure began in Jackson Elementary School in Akron. The CBE learning stations at Seiberling and previously at Forest Hill had been placed in Learning Resource Centers. At Jackson the CBE Learning Station was installed within a sixth grade classroom to serve as a support system in mathematics for the dual purpose of remediation and enrichment.

The Jackson experience has provided some valuable insights into a successful CBE program. "A key variable in student achievement and in the attitudes of both the teachers and students seems to be the degree of personal and professional involvement demonstrated by the teacher. The largest gains in achievement have been noted in situations such as the one at Jackson Elementary School. The teacher's involvement there includes one of supervision of the terminal area (it is located in his classroom), a pre-project interest in computing education (he used CBE as a

student and studied it as a student at The University of Akron), and a request to be granted use of the computer assisted math course." Hirschbuhl and Myers (1979)

Results of the Jackson Study

A sixth grade class at Jackson School received the prescribed mathematics curriculum using traditional instructional methods and was supplemented with 15 minute daily CBE sessions. The control group, another sixth grade class in the same building, received only conventional classroom instruction of the prescribed mathematics curriculum. Both groups were pre and post-tested using alternate forms (from pre and post-testing) of the California Achievement Test. Once again, the results of the CBE group of an average gain of 3.5 grade levels in contrasted with the control group's gain of 1.6 grade levels.

The teacher involved in the project stated, "Overall, this additional classroom tool (CBE) has stimulated students in their academic achievement. Personally, I have been able to introduce and teach more concepts than in any previous year."

Buchtel

The latest involvement with Computer Based Education in Akron City Schools has been the incorporation of CBE into the Buchtel High School Project. In a bold effort to reduce the black-white dichotomous type of society emerging in their city, Akron developed a three million dollar magnet school project in 1977 in an inner-city neighborhood. The CBE terminals were placed in the library of Buchtel High School to serve the academically talented student. Course offerings included Psychology, French, Spanish, Basic English, Chemistry, Mathematics, and Reading.

Because Buchtel High School was in a period of transition, the CBE stations were favored by the faculty for remediation in basic skills and became a major tool for that purpose. For the 1979 school year, the major thrust of the program is to serve the needs of the mathematically and scientifically gifted students. A portion of the program will continue support in the basic skills area. The coordinator of the CBE Center at Buchtel High School stated in January, 1979, "It (the CBE Center) has become a vital part of Buchtel High School. It is used by students on their own initiative as well as by students through teacher recommendations."

A problem which occurred at the outset of the program was readily solved. The problem involved the scheduling of computer time to fit the students' regular class schedules. During some periods of the day, student requests for terminal time exceeded the availability; yet, during other periods, there were times when one or more of the three terminals were unused. This problem was solved by allowing the library student population in any given period to use unoccupied terminals. According to the coordinator, "This has provided greater flexibility and greater ability to serve more students." As a result of this project, many Buchtel students have become comptuer literate.

Results of the Buchtel Project

The following is a report on the usage of the CBE terminals at Buchtel during the 1978-79 school year:

141 students signed up and were assigned to a computer terminal on a course of their own choosing.

21 students dropped out due to the course not being helpful or due to no follow through on their part.

3 students dropped out by request of CBE personnel due to misuse of computer time.

4 students dropped from the computer course and transferred to a one-to-one tutoring program.

3 students dropped because of changes in their schedules.

102 students completed their courses.

SUMMIT COUNTY JUVENILE COURT

CBE Learning Stations were set up for the past three years in the Summit County Juvenile Court which is located in Akron. The Juvenile Court's chief objective in the program was to reduce recidivism in young offenders. Subliminal cueing designed toward the tenets of anti-crime philosophy was implanted in the skill lessons for the young offenders.

Results of the Juvenile Court Study

There have been mixed results in this very innovative and experimental program. It serves youngsters ages 9 to 12. One of the major problems in the collection of data has been the very short time a youngster spends at the Center using a CBE program. The program was designed to research the effects of the inherent anti-crime principles programmed into the

instruction. Additionally, it was hoped that these youngsters, the majority of whom is sadly deficient in reading, would at least receive a beginning or a grounding in basic skills and a bridge be built with their teachers to continue the work. Some of the findings are as follows: The effectiveness of LEAVE was less than that of the regular court program. It was concluded that one major factor contributed to this effect; the LEAVE program was devoid of the necessary reinforcements due to the total neglect of administering a defined point system. The original design incorporated concrete rewards as various levels of points were achieved. As the program was carried out, the subjects could not lose, and few incentives for good performance were administered. A large number of the CBE group who recidivated did so within a few days after completing the program. This indicates that the program had a definite effect. The effect was that many offenders were acting out a desire for controls. The CBE group had very few controls since there were no options except to win. To make the program effective, the point system must be given meaning and periodic reinforcements must be given.

REVERE LOCAL SCHOOLS

Revere Local Schools in Bath Township just outside of Akron documentated the achievement of their CBE students in several areas during the 1977-78 school year. Reading levels of the sixth grade students at Bath Elementary were assessed at the beginning of the year. Two months of daily computer instruction supplemented the second semester's curriculum. The instructor and the materials were the same for both semesters.

Results of the Revere Study

The students gained an average of 2.4 months more in reading proficiency during the semester they were on the computer than during the semester they were not on the terminal.

Achievement in metrics was also studied in the Bath accelerated sixth grade mathematics class which used CBE. Two post-tests were administered. One test was given immediately after completion of the metric unit and the other two months later. The results were compared to the test scores of previous accelerated classes which had not received CBE supplementation. "Not only did the class with the assistance of the computer have better scores and retain more knowledge after that two months, but they also spent about one week less time doing the metric unit that the instructor had prepared from many sources." Dalton (1978) The 1978-79 studies paralleled the above studies and were found not to be statistically significantly different. Dalton (1979)

An increase in computer literacy was also observed at Bath Elementary. According to the teacher involved, "the student became literate about computer vocabulary and use which will play an important part in his future life." Eighty-nine percent of the students answered all questions correctly in response to a short "computer literacy" checklist. Dalton (1978)

PORTAGE COUNTY

Woodridge, Akron, and Revere are located in Summit County as is The University of Akron. Portage County, which borders Summit County on the east, has actively worked with the CBE network as well as the other areas of the technology.

Portage County hosted a large inservice program for Ohio's elementary and secondary teachers in October, 1977. CBE was given special prominence at that conference. The first Computer Literacy Conferences in the state were held in 1978 and 1979 and were sponsored jointly by The Portage County Board of Education and The University of Akron. One outcome of these conferences was that Katherine Hirschbuhl, a consultant with the Portage County Board of Education, was made a member of the Ohio Advisory Committee for Educational Information Systems so that instructional applications would be better represented at the state level.

Another outcome of these conferences was the formation of The Portage County Computer Literacy Committee. This committee has superintendents, physics teachers, elementary teachers, curriculum directors, and representation from every area of education. All of the work in Portage County has been done in cooperation with The University of Akron's CBE Network.

WATERLOO LOCAL SCHOOLS

A computer terminal was used for remediation in the 7th and 8th grade English program at Waterloo Middle School. The more seriously disabled readers received daily CBE lessons for one school year. The Reading Specialist reported an average gain of 1.5 years growth for the 62 youngsters receiving help.

ROOTSTOWN LOCAL SCHOOLS

Rootstown Elementary (Berthe Bradshaw) School reported approximately the same results as Waterloo. In both schools, the CBE Learning Station was set apart from the classroom with no aide and little indirect supervision. Despite a few anticipated problems, the learning situation had positive results.

A new CBE Learning Station was placed in Berthe Bradshaw this year, but it has been set up in the Reading Coordinator's classroom. She held "Open House" for 4th and 5th grade parents to learn about CBE. The University of Akron's CBE Network Liaison, Carolyn Myers, held a Computer Literacy meeting with parents. The school is using the program for both remedial reading and for the gifted/talented child in Language Arts. The staff has developed an extensive Language Arts Enrichment Program for 4th and 5th graders with CBE at its hub.

CUYAHOGA COUNTY

CUYAHOGA HEIGHTS SCHOOLS

Located in a suburb of Cleveland, the Cuyahoga Heights High School utilizes two CBE terminals. During the 1979-80 school year, approximately 150 students from three mathematics levels were required to take seven different CBE mathematics courses.

All English classes used the Basic English course for its remedial program as well as for on-level drill-and-practice. With such a heavy demand for usage and only two terminals, Cuyahoga Heights has devised a very efficient schedule for CBE sessions. CBE coursework has been built into the school-wide curriculum making it a vital part of the educational process at Cuyahoga Heights High School.

RICHLAND COUNTY

PIONEER JOINT VOCATIONAL SCHOOL DISTRICT

Pioneer Joint Vocational School is located in Shelby, Ohio, and serves the school population of three surrounding counties. CBE is a central part of Pioneer's Extensive Basic Skills Improvement Curriculum. Fifty students a day are provided lessons in reading and mathematics without additional staffing. All students entering Pioneer are given diagnostic tests to determine basic skills levels. These test results are the basis for selection for CBE students along with referral from the academic or vocational instructors. The coordinator of the program emphasized the computer literacy aspect of CBE in an article in the Mansfield (Ohio) News Journal (February 19, 1979), "Not only does working with computers increase a student's self-image, it also gives them training on a machine that might possibly be used in their chosen field."

MEDINA COUNTY

CLOVERLEAF LOCAL SCHOOLS

The remedial reading program at Cloverleaf Junior High School incorporated CBE courses into the curriculum for students who score two or more grade levels below actual grade level on the Nelson-Denney Reading Test administered in September of each school year. Approximately 50 students received this remedial instruction each year. The reading specialist reported improved attitudes toward reading as a major result of the CBE experience.

WAYNE COUNTY

WAYNE COUNTY GENERAL AND TECHNICAL COLLEGE

Wayne College is a branch of The University of Akron located about 35 miles southwest of the main campus in rural Wayne County. The greatest utilization at Wayne College has come from the mathematics and science departments with CBE courses becoming an integral part of the calculus and chemistry curricula.

During the 1979-80 academic year, Wayne College will participate in a study of computer literacy assessing knowledge of computers and attitudes toward their use. The study will be patterned after the August, 1979, study by the Minnesota Educational Computing Consortium. Anderson et.al. (1979)

SUMMARY

In terms of perceived impacts on learning that CBE has had on Ohio's schools, it is significant to note that "The Technology and Its Implications for Educators" has been set as one of the major themes for 1980, The Year of the School in Ohio, by the State Superintendent of Ohio's schools. Hirschbuhl (1979)

The Summit County Children's Home is in the process of implementing nineteen terminals on The University's CBE network. Warren (Ohio) Public Schools, further east, are implementing 12 terminals. There has been more demand than we can meet at this time. We are working hard to meet the challenge. Because of continuing advances

in hardware and software that are currently taking place, it is reasonable to assume that we will meet the challenge.

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THE JACKSON ELEMENTARY SCHOOL

COMPUTER BASED EDUCATION MATHEMATICS PROJECT

THOMAS WARNER

THE UNIVERSITY OF AKRON

ABSTRACT

During the 1978-79 school year, two sixth grade mathematics classes at Jackson Elementary School in Akron, Ohio, were involved in a study to determine the effects of the daily integration of 15 minutes of Computer Based Education (CBE) mathematics instruction as compared with exclusive non-CBE instruction. Students receiving CBE mathematics instruction achieved significantly higher scores on the California Achievement Test and exhibited more favorable attitudinal responses concerning mathematics learning than those students not receiving CBE instruction. The study demonstrates that the use of Akron's CBE mathematics curricula can be a very powerful tool in the hands of a competent teacher.

REVIEW OF THE LITERATURE

Three Major CBE Basic Skills Mathematics Courses

Prior to the development and effective implementation of comprehensive, carefully designed CBE Basic Skills Mathematics curricula, an often reported result of research on the use of CBE Basic Skills Mathematics courseware was "an improvement in time spent, but no significant achievement difference." Hall (1974), Wiley (1975) Three extensive CBE Basic Skills Mathematics curricula which have proven very effective in improving achievement and promoting favorable attitudinal shifts in student users are described below.

During the late 1960's, under the leadership of Dr. Patrick Suppes, the Computer Curriculum Corporation (CCC) created drill-and-practice CBE mathematics strands for grades 1 through 6. Students work simultaneously on several concept areas, or strands, progressing upward (toward more difficult exercises) on each strand based upon their performance. If criteria are not met, the student is cycled through remedial exercises. Detailed descriptions of the design and curricular content can be found in Suppes, et.al. (1972)

Funded totally by the Control Data Education Company, Dr. Ralph Heimer of The University of Pennsylvania developed a Basic Skills Mathematics curriculum implemented via the PLATO system and aimed at the adult learner. Objectives are organized into clusters; interrelated clusters are packaged into bundles, over which mixed practice and retention tests are administered. The curriculum is divided into nine major subsets called strands (addition, subtraction, etc.)

Each cluster of objectives consists of the following set of instructional activities: a tutorial lesson, a drill-and-practice lesson, a set of exercises in the student Strand Booklet, a mastery test, and a review help sequence. Heimer and Rizza (1978)

In addition to Dr. Heimer's curriculum, the mid-1970's also saw the development of a CBE Elementary Mathematics curriculum at The University of Akron, designed and written by Dr. John Hirschbuhl and the CBE staff. This curriculum, implemented via IBM's Interactive Instructional System, is used throughout the United States and the Far East. The five major content sections are: Addition and Subtraction of Whole Numbers; Multiplication and Division of Whole Numbers; Fractions; Decimals; and Rations, Proportions, & Percents. Each major section is composed of hierarchical and content

specific sub-sections, which in turn are broken down into sequenced objectives.

This modular design enables an objective to be taught within a teacher determined session, usually 10-15 minutes. A comprehensive test is administered after the student has demonstrated mastery of all objectives within a given cluster. Each objective follows a pretest-tutorial-randomized drill-puzzle design. Further discussion of the design with a general flow chart can be found in the next section; also see Hirschbuhl (1978).

Achievement and Attitudinal Gains

Significant achievement and attitudinal improvements in students who spent ten minutes a day on CCC's drill-and-practice mathematics strands are reported by Pettey (1977), Poulsen and Macken (1978), and Hunter and Hargan (1978). Similar results were found in Chicago, where over 1,000 students have made daily use of CCC's strands for many years. Litman (1973), Hunter and Hargan (1978) Hunter and Hargan (1971) also describe exemplary success stories in Dallas, Delaware, and New York. An Educational Testing Service five-year study duplicated these significant gains in achievement and attitudinal improvements and additionally provided a basis for the claim of cost-effectiveness of this use of CBE. ETS (1979)

Various PLATO Basic Skills mathematics courses have been shown to significantly improve achievements and attitudes as well as influence CBE project participants to enthusiastically take more responsibility for their own work. Stake (1978), Dugdale and Kibbey (1977)

Use of the CBE elementary mathematics curriculum developed at The University of Akron has also demonstrated a resultant significantly higher achievement and attitudinal gains. As this paper documents and as reported by Hirschbuhl and Myers (1979), there has been a greater participation of parents in their child's education.

Henry Palmer (1973) observed that use of CCC's Mathematics strands improves achievement and that the time spent on CBE was better spent than if that time had been spent on regular instruction. Other success stories in CBE Basic Skills Mathematics curriculum can be found when CBE is applied to the American Indian, Suppes, Fletcher, and Zanotti (1975) gifted students, Suppes and Ihrke (1970) and Slatton (1977) and deaf and hearing-impaired students. Suppes and Fletcher (1976), Holbrook (1977) and Kearsley (1979) Many studies verify that the use of CBE, especially among minority groups, can greatly enhance the child's locus of control, which is usually coupled with higher achievement. Smith (1973), Fisher (1974), Crandall (1976), Los Nietos Studies (1977)

PROJECT DESCRIPTION

The experimental hypothesis: For elementary students, integration of Akron's CBE elementary mathematics curriculum into the regular classroom instruction will (1) increase mathematics achievement, and (2) produce favorable attitudinal shifts toward mathematics learning.

The School

Two sixth grade math classes at Jackson Elementary School in Akron, Ohio, were involved in a CBE project during the 1978-79 school year. The student population is average, middle-class, and predominantly white. Based on overall aptitude and achievement, students were randomly assigned to the math classes in matched pairs. The two classes were pretested using the California Achievement Test. The class averages were within .10 of a grade level on the pretest.

Mr. Robert Hanna taught the non-CBE group, and Mr. Larry Marshall taught the CBE group. Identical objectives, texts, and homework assignments were given to both classes. See Ott (1979) for details on the Mathematics Management System and a list of all teacher assignments. Mr. Marshall used CBE as a part of the regular classroom instruction. Each of his 21 students received 15 minutes of CBE daily. The single teleray terminal located in Mr. Marshall's classroom was hooked up to The University of Akron's computer.

The CBE Curriculum

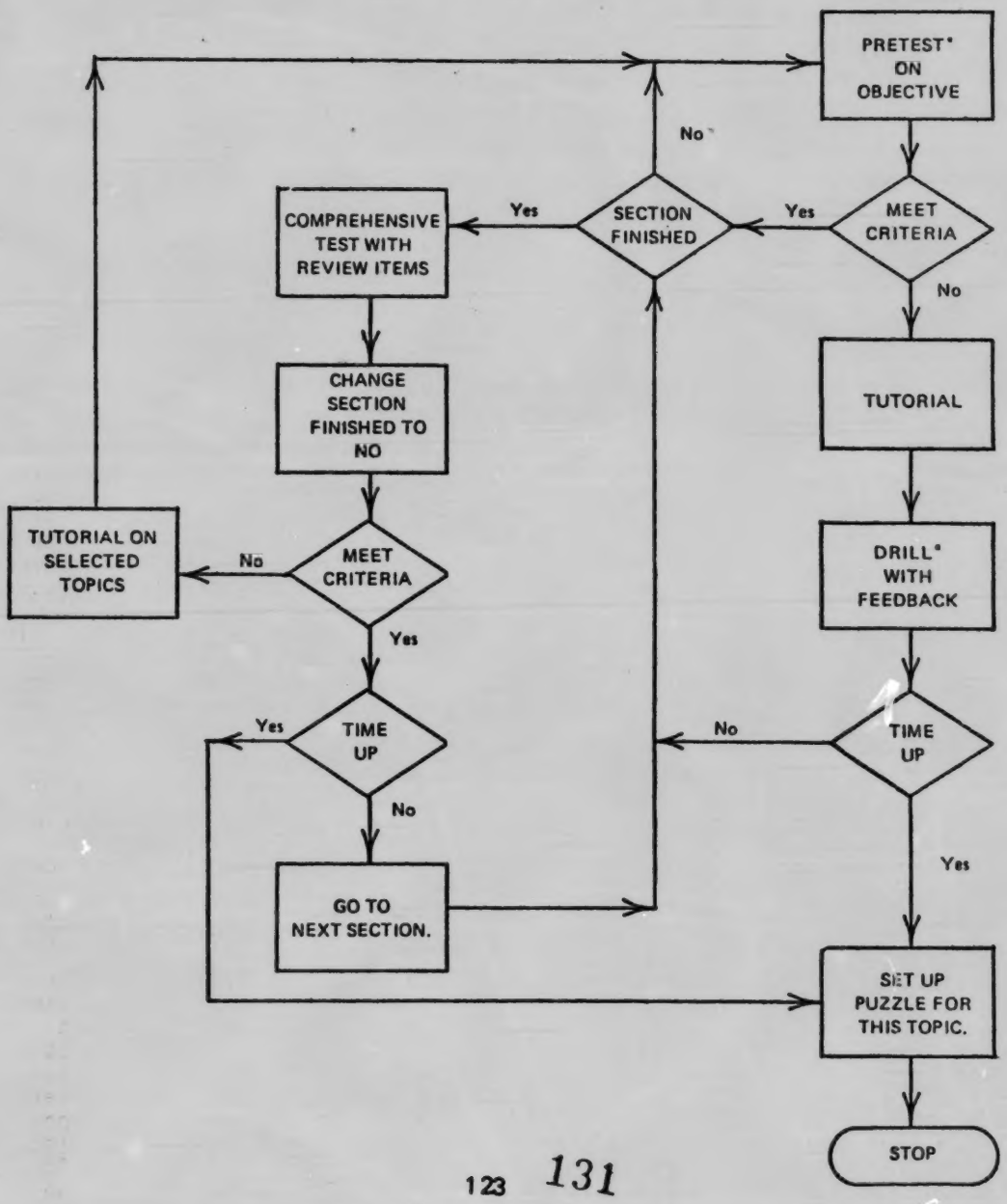
Students began working on the Addition section of the CBE curriculum in order to resolve any skill deficiencies. Each major section in the CBE curriculum is divided into hierarchical and content specific sub-sections, which are in turn broken down into sequenced objectives. See Hirschbuhl (1978) for a list of objectives. The logic for each sub-section is depicted in the following flow chart.

Within a sub-section (i.e. a cluster of interrelated objectives), a student proceeds from pretest to pretest until a question is missed, whereupon he immediately is sent to the individualized tutorial for that objective. After completion of the drill and puzzle, the student

proceeds to the pretest of the next objective. A comprehensive test is administered after completion of all objectives within a sub-section. This comprehensive test contains items from lower order sub-sections within the given major section in order to test retention. Based upon test performance, the student is sent back through various tutorial(s) and drill(s) or proceeds to the next sub-section.

Mr. Marshall examined weekly detailed reports which related information concerning number of objectives passed by pretest in any given sub-section, time-outs, objectives repeated, and all test scores. Through the use of these reports, Mr. Marshall was able to more effectively and efficiently address any particular problems his students exhibited.

FLOW CHART OF GENERAL INSTRUCTION STRATEGY
AND COMPREHENSIVE TESTING SYSTEM



ANALYSIS AND RESULTS

The two classes were pre- and post-tested in the areas of computation and application using the California Achievement Test. The difference between pre- and post-test raw scores was tabulated for each student. These sets of difference scores were used as input data for subsequent statistical analysis.

To account for the correlation between the computation and application scores, a multi-variate analysis of covariance was used to measure the indpendent treatment effect on computation and application skills. The biomedical computer program BMDP3D was used with the following results:

Hotellings T^2	29.27
F Value	9.23; $p < .001$; df = 3,38

Hotellings T^2 is simply the square of the maximum possible univariate t computed on any linear combination of the various outcome measures.

If the dependent means are sampled from a multivariate normal distribution, the sampling distribution of T^2 has the same shape as the F distribution.

$F = \frac{N-P}{P(N-1)} T^2$, with p and N-p degrees of freedom. Harris (1975) Our computed F-Value is 9.27, which is highly significant ($p < .001$).

The individually computed t values show that there is a significant difference between the means of the CAI and Non-CAI groups for both the computation and the application ($p < .002$). Equal n's of greater than 20 assures us that non-homogeneity of variance will have little effect.

Differences on Single Variables

Computation

Statistics		P Value	D.F.	Group	CAI	Non-CAI
T (separate)	4.57	0.000	33,5	Mean	15.05	8.19
T (pooled)	4.57	0.000	40	Std. Dev.	5.83	3.63
F (For Variance)	3.59	0.039	20,20	N	21	21

Application

Statistics		P Value	D.F.	Group	CAI	Non-CAI
T (separate)	3.37	0.002	37,1	Mean	10.81	4.86
T (pooled)	3.37	0.002	40	Std. Dev.	6.49	4.86
F (For Variance)	1.78	0.206	20,20	N	21	21

Attitudinal surveys were given to Mr. Marshall, to each of his students, and to the students' parents.

INTERPRETATION

Statistical

Hotellings T^2 provides a means of testing the overall null hypothesis that the two populations from which the two groups were sampled do not differ in their means on any of the p measures.

Attitudinal

Mr. Marshall found the CBE courses very beneficial in providing his students with the extra instruction and remediation that they required as well as in diagnosing specific learning deficiencies. He felt that he was able to reach more students more effectively, that his students achieved significantly higher, and that their attitudes toward Mathematics learning improved more as compared to his previous years of teaching without CBE.

Nearly all of the students liked working on the computer math course, felt that the CBE helped them in their math class and with their homework, and would like to continue using the CBE math course. Parents felt that their children benefited from the use of the CBE math course and hoped that their children could continue to use CBE. For details see Hirschbuhl and Myers (1979).

CONCLUSION

When integrated into the curriculum, the CBE Mathematics course developed at The University of Akron can significantly improve achievement in and attitudes toward mathematics. The improvements in both computation and application, as measured by the CAT indicates that students who made use of the CBE Mathematics course were more proficient and were better able to transfer their knowledge.

One cannot conclude from this study that CBE instruction, using The University of Akron's mathematics curriculum, is more effective than classroom teaching or even that every teacher using this curriculum as part of their regular instruction will obtain increased student achievement and improved favorable student attitudes toward learning. Since there were two teachers involved, one must take into account the variability in teaching style.

However, this study does show quite conclusively that use of Akron's CBE elementary mathematics curriculum can be a very powerful tool in the hands of a competent teacher. In his nine years of teaching, Mr. Marshall never experienced such increases in student achievement and motivation.

More research, under varying environments and more controlled situations, is needed to demonstrate the true power, versatility, and usefulness of this CBE mathematics curriculum. Future research at The University of Akron will examine the impact of the mathematics curriculum when a terminal is placed in Mr. Hanna's classroom.

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The Marine Corps Mastery Learning Project: Effect of Self-Paced Course Reorganization on Learning Time and Achievement

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Abstract

A two-week group-paced military electronics course was converted to a self-paced mastery learning strategy by grouping objectives into four instructional blocks. Pacing was managed by randomly selected formative examinations administered by computer terminals. Initial decrements in student performance on summative examinations were overcome by the fourth iteration of the experiment. A 30 per cent time saving was found in all four experiments.

Introduction

This investigation was designed to implement Bloom's (1968) notion that a sensitive, adaptive, personalized instructional system could enable over 90 percent of its students to learn at a level previously attained by only 10 percent in traditional instruction. The adaptivity of such learning for mastery is based on a model asserting that the degree of learning is a function of the time a student actually spends in contact with the subject matter relative to the time the student needs to spend (Carroll, 1963). Mastery Learning (ML) begins with the assumption that all students can learn; then, in its allowance for learning time to vary in accordance with individual human needs, ML provides repeated support, instruction, and corrective activity to students until they have successfully attained the instructional objectives. The research presented in this paper describes four repetitions of an experiment that did not at first achieve parity in achievement. In a sense, an ML spirit prevailed in attempts to do the experiment again and again, diagnosing difficulties and prescribing corrective action, until such parity was achieved. The major goal in these experiments was to train cohorts of students to criterion in less time than required under traditional lock-step instructional methods.

While time for learning is of concern in ML applications it is particularly important in military instruction, where students receive salary and benefits during their courses of study. Earlier studies have revealed consistent time savings in three years' experience using a microcomputer to manage students' self-paced progression through a course (Evans and Johns, 1979). Orlansky and String (1979), in an iconoclastic attack on the cost-effectiveness of 30 studies of military computer-based education (CBE) have still concluded that a 30 percent time saving is possible. However, computer management is not essential to capturing such time savings; Keller's (1968) Personalized System of Instruction (PSI) allows self-pacing without using computers. PSI has worked well in studies with individual classes. But is such management possible in a school of, say, 2000 students progressing through 45 military occupational specialties at 2000 rates of speed? Licklider (1979) reasons that the cost-effectiveness of computer hardware doubles every two years. This being so, the time seems right for using this technology to personalize instruction, while saving time and dollars.

Thus, with the competence claims of ML, the time savings of PSI, and the management possibilities of CBE enticing us, we are enjoined to the

hypothesis that students who are provided a mastery-fixed time-variable learning environment will attain course objectives in fewer days than students undergoing traditional mastery-variable time-fixed instruction.

Design

Treatment

All subjects were enrolled in the Fundamentals of Digital Logic (FDLC) course at the Marine Corps Communication-Electronics Schools. In the lock-step mode, FDLC is a two week or ten class-day course involving 76 hours of lectures, discussions, demonstrations, and homework. The course deals with basic concepts of digital logic, logic circuitry, programming, and storage devices which are necessary for communication, radar, and tactical data systems. The control groups took this treatment in two segments, with a non-cumulative summative examination after each five-day period.

The experimental treatment grouped the same FDLC objectives into four instructional blocks, each culminating in a formative examination, with a single cumulative summative examination, given ten days after the course began.

Formative examinations were composed of 15-20 multiple-choice questions randomly selected from an item pool, and administered at a computer terminal in a manner described elsewhere (Surkan and Evans, 1978). The student would answer until a correct choice had been made; then, a feedback frame would present an explanation of the question. After 15 or 20 such questions, answer, and feedback cycles a score was calculated. If the score was less than a 85 or 90 percent mastery criterion, the students were required to meet with the instructor. In this meeting a print-out of each of the students' interactions with the computer during the testing period was available to expedite the instructor's diagnosis of learning difficulties. (This process is illustrated in Figure 1.) After diagnosis, a prescription was further directed study, usually under the direction of a Graduate Assistant (GA). The GAs were students who had completed the course in a previous class and were serving temporarily in this role while awaiting further assignment in the school. GAs. The classrooms were open for 10-15 hours per day.

For the summative examination, a different mastery criterion existed. The control groups used the 70 percent criterion which had been the school policy. The experimental groups used an 80 percent criterion. Students who failed to attain this experimental criterion were required to return for extra instruction on the day following the scheduled summative examination.

In summary, the treatment differences between the control and the experimental groups were such that the experimental groups were more labor-intensive and featured more testing. They included more human interaction over longer working hours than were the more mechanistic, depersonalized, lock-step control groups.

Variables

Two criteria determined experimental outcomes. The first, Days to Mastery, was calculated as the number of days since the FDLC course began until the students attained mastery on their fourth formative examination. This varied according to individual differences among students in the experimental groups, but was fixed at 9.5 days for students in the group-paced control groups. The second criterion, Summative Examination Scores, was based on paper-and-pencil 56 multiple-choice question comprehensive examinations for the four experimental groups and for the last control group. All other control groups had 28 question examinations on the fifth and tenth day of their group-paced instruction. The summative examinations were unique for each group with questions being randomly selected from an FDLC item pool. Additionally, the fourth iteration of this experiment utilized a second summative examination involving 56 application-level questions specially prepared for the FDLC instructional objectives.

Although it was not directly related to the hypothesis, Rotter's Internal-External Locus of Control scale (1966) was administered in an effort to seek a predictor of time to mastery in the self-paced instructional environment. This need did not become apparent until completion of the first experiment, and was administered Each experimental group had two instructors, who each had two to five

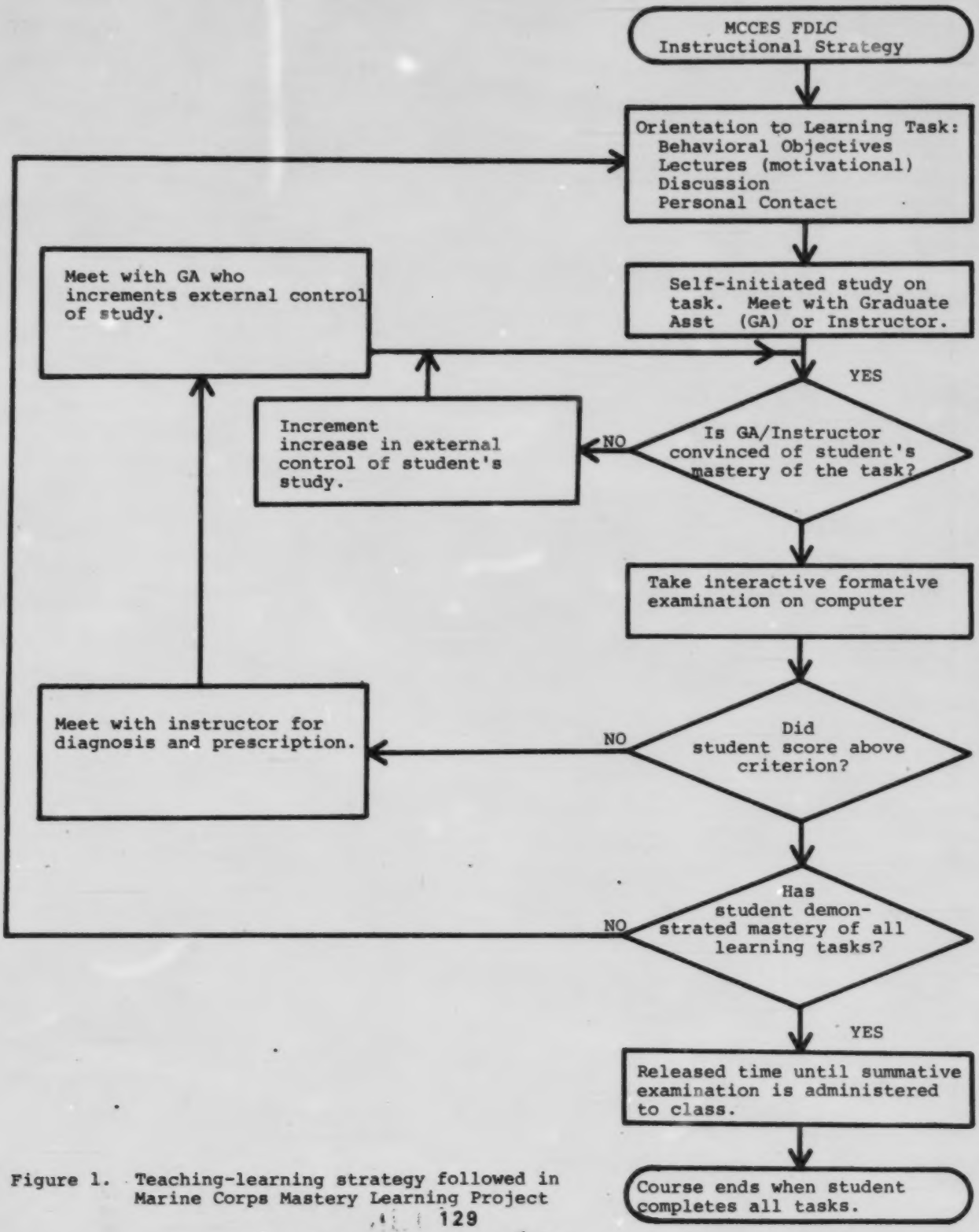

Figure 1. Teaching-learning strategy followed in Marine Corps Mastery Learning Project

to each experimental group thereafter.

Experiment 1

Method

Subjects. Twenty-two Marines, including two women, were enrolled in the experimental class. Controls were 178 members of the previous four FDLC classes. The students were roughly equivalent with college sophomores--about 20 years of age and the 80th percentile in Army General Classification Test (AGCT scores). No significant differences were found amoung the five classes in Nelson Reading Test scores, grades in a mathematics prep course, AGCT scores, or previous math background ($p > .05$).

Treatment. There were two instructors and four GAs for the experimental group. The students' day began with a three-mile run at 0600, and a class meeting at 0800. Those who were ahead of the lock-step schedule followed by the control groups, were free to come and go until the classroom closed at 2100 hours. A IBM 5110 portable micro-computer administered 15 question formative examinations. Since there was some queuing, an appointment schedule was established which kept this machine occupied most of the time. The computer scored these examinations utilizing a partial-scoring procedure of 3-2-1-0 points per question, depending on the number of attempts required to choose the correct answer. The criterion for mastery was 90 percent.

Results. Table 1 displays the results of all four iterations of this experiment across salient variables. Here it may be seen that the EXP1 group took significantly fewer days to mastery than the previous control groups ($t = -11.09$, $df = 21$, $p < .001$), and scored significantly lower on the summative examination ($t = 4.31$, $df = 41$, $p < .01$). The class averaged 5.81 formative exam attempts in order to demonstrate mastery of all four examinations. These same students reported an average of 34.43 hours of independent study to demonstrate their mastery.

Experiment 2

Method

Subjects. There were 22 male and two female Marines enrolled in this experimental group. The controls did not change from the previous experiment. No significant differences were found among any of the equating variables used previously.

Treatment. This experiment differed from the former in that the number of instructors was reduced to one full-time and one part-time, classroom hours were reduced from 13 to 10, class was adjourned over the week-end, scoring of formative examinations was changed from a partial-score to a right/wrong scoring procedure, introduction of a number of instructor-led reviews of course content, external control of study time of slower students was tightened, and the Internal-External (IE) Scale was administered. Because of the increased stringency of right-wrong scoring, the mastery criterion for formative examinations was lowered to 85 percent.

Results. In spite of the foregoing variations in treatment the findings were similar to the previous experiment. As may be seen in column two of Table 1, the EXP2 group had a significant mean time reduction of 2.25 days less than the 9.5 days required in lock-step instruction ($t = -14.95$, $df = 23$, $p < .001$), and scored significantly lower than the mean examination percent scores of the combined control groups ($t = 6.30$, $df = 176$, $p < .001$). They averaged 5.71 attempts on the formative examinations even though the change in scoring procedure tacitly raised the mastery criteria, and they reported a mean of 28.70 hours of study in the course. The IE scores correlated zero to low with days to mastery, as shown in Table 2.

Experiment 3

Method

Subjects. This class differed from the others in that the 17 students were all males and six were senior non-commissioned officers ranging in age to 32 years. Their mean AGCT score put them in the 86th percentile.

Treatment. Two master instructors and six graduate assistants were involved in this experiment. The right-wrong scoring procedure with its accompanying 85 percent mastery criterion was retained for the formative examinations. Group physical fitness was again a special part of the experimental group's treatment with a timed three-mile run being the first activity of every class day.

Results. Once again the findings (EXP3 shown in Table 1) revealed no unusual results. The 7.41 days to mastery was less than that of the control groups ($t = -9.99$, $df = 16$,

Table 1

Mean Scores of Groups on Criteria

CRITERION	GROUP EXP1	EXP2	EXP3	COMBINED CONTROLS	EXP4	CONT4
Days to Mastery	7.09	7.25	7.41	9.50	6.18	9.50
Summative %	79.35	79.33	79.29	88.72	82.33	83.92
Formative Attempts	5.81	5.71	6.82	--	8.06	--
Hours Study	34.43	28.70	35.88	70.00	--	70.00
Second Summative Raw Scores	--	--	--	--	40.81	37.92
No. Cases	22	24	17	178	16	13

Table 2

Product-Moment Correlations of IE Scale with
Days to Mastery Across Four Formative Examinations

Experiment	Formative Examination F1	F2	F3	F4
EXP2 df=22	.37	.07	.00	.24
df=15	.30	.39	.42	.48*
EXP4 df=14	-.60*	-.48	-.40	-.62*

*$p < .05$

$p < .001$) while the average summative examination score was also less ($t = -8.65$, $df = 169$, $p < .001$). The class averaged 6.82 attempts to master the four formative examinations, and they reported 35.88 hours of study in doing so. The IE scale correlations are shown in Table 2; here, low to moderate positive correlations were found.

Experiment 4

Method

Subjects. The subjects for this iteration of the experiment were very similar to those in EXP1 and EXP2, and included 14 male and two female Marines. All fourteen of the control group were males.

Treatment. There were two instructors involved this time--including one senior instructor who had not previously been involved with the project and one who had been assigned to experiment 3. There were three graduate assistants. This time a control group was scheduled to run concurrently with the experimentals, with its own summative examination scheduled for day 10 in the manner followed by all of the four experimental groups.

Since a concurrent control group allowed for a more precise experiment, a second summative examination was prepared independently of the instructors involved in the experimental and control groups. This tested higher-level cognitive performance than the traditional summatives, and was administered first on Day 10.

The four formative examinations had been carefully screened and improved prior to commencement of this experiment. To avoid unnecessary time delays for students, the software package (written in APL and operating on a single IBM 5110 microcomputer) was translated into DATABUS and made resident in a Datapoint 6600 minicomputer with four terminals for interactive student testing. The elimination of student queuing for tests permitted increasing the number of questions in each formative examination from 15 to 20.

The classroom was open for about 13 hours each day, but all students spent an hour or more in the middle of the day in physical training. External control was increased, requiring all students to be present in the classroom approximately eight hours per day, with the inducements of time off and the opportunity to drive an M-60 tank after completion of the fourth formative examination. One additional restraint was the requirement that all students return from their days off on Day 9 for a review session, much in the manner that provided for the control group.

Results. Table 1 contrasts the two groups in columns 5 and 6. This treatment produced the greatest saving in time to mastery which had been found to date. The 3.32 days saved was significant ($t = -15.88$, $df = 15$, $p < .001$) with no significant differences between the two groups on either of the two summative examinations. Results of correlating IE scores with days to mastery revealed moderate negative values.

Discussion

Experience with the four iterations of this experiment has led us to accept the hypothesis that a self-paced, mastery learning strategy will provide significant time savings over the more lock-step, group-paced instruction. The results translate into 25, 24, 22 and 35 percent time savings, respectively, although these savings were attained at the expense of summative examination performance in the first three experiments. We are sensitive to the scientific incongruity of repeating an experiment until getting the desired results. However, both Block and Burns (1976) and Kulik and Kulik (1975) have presented extensive reviews of the literature that show no such decrement in performance in either ML or PSI studies. Other studies (Anderson, 1976; Block and Tierney, 1974; Evans and Johns, 1979; Morris, Surber and Bijou, 1978) are particularly supportive of this notion. Such evidence suggests that the lowered summative examination performance by the experimental groups in the first three experiments was due to something other than the self-paced Mastery Learning strategy under investigation. Open-ended critiques by both students and instructors point toward the scarcity of printed materials and summative examination items keyed to the instructional objectives. In group-paced instruction the lecturer covered tacit objectives in class while this was not done in the first three experimental groups. By the fourth experiment, both printed material in the study guides and the content validity

of one of the summative examinations has been improved. Therefore, we concur with the results of the fourth experiment and the trend in the literature by concluding that a 30 percent time saving is possible with no decrement in performance when using a self-paced, Mastery Learning, instructional strategy. Furthermore, we believe that even greater time savings and higher performance levels are possible when the instructional packages are developed with coherent objectives, individualized instructional materials, and summative examinations.

The hours of study reported by students, ranging from 29 to 36 in the first three experiments, were determined by the instructors to be erroneous, and in the fourth experiment a self-reported time log was not kept. This was substituted by more external control of the students during the normal working hours of the experimental groups. Students were required to be present during the eight-hour class-day, with the classroom and computer facilities being available an additional four hours for students who were motivated to put in more study time. This shift to external control by the instructors may have accounted for the dramatic shift in the relationship between scores on the internal-external locus of control scale and days to mastery of the four formative examinations. The low to moderate positive relationships found during the relative freedom of the third experiment would suggest that internally controlled subjects should complete the instructional modules in less time. The moderate negative relationships found in the fourth experiment occurred when increased external control was exerted by the instructors, and the more externally controlled subjects actually completed the modules in less time. While the explanation for this phenomenon has not been determined, earlier studies have found days to mastery to be alterable by external control (Evans and Johns, 1979) and related to hours of study (Evans and Duncan, 1979). If the student reports of time spent studying were indeed close to being accurate, then they were achieving a mastery level equivalent to that of the control groups in 30 percent less days to mastery while being engaged with the subject matter less than half as long (about 35 hours, compared to 76 hours). This unused time, which has been wasted as far as the instructional objectives are concerned, should tempt an alert instructional technology to find even greater savings in time to mastery than those presented in this investigation.

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Computer Based Education in Military Technical Training

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Abstract

The efficiency and effectiveness of contemporary military technical training systems is decreasing because of technological, manpower and monetary changes in the environment. Short-ranged actions within these training systems are insufficiently productive. A major change in instructional delivery and management is required. This change, the application of computer technology in the form of computer based education, will allow the training systems to be more flexiable and responsive to future changes while maintaining high productivity.

Introduction

The efficiency and effectiveness of contemporary military technical training systems is decreasing and this trend will continue unless major changes are made in the present method of management and presentation of instruction. The managers of training systems are facing increasing difficulties in accomplishing their training mission because the instructor staff is being reduced, the operational budget is being cut, and the workload is increasing. The students are less qualified in the basic skills than they used to be, and there are less of them available to fill the seats. Finally, more graduates must be produced, each possessing a greater array of skills, but the managers have less time to accomplish this. Training managers are trying to meet all of these demands with a training system that is outdated, has passed the zenith of optimum productivity, and fails to respond to further temporary fixes or short-ranged solutions. With a few notable exceptions, the military training managers have been attempting to cope with changing conditions and new requirements with a system that has remained relatively unchanged since World War II.

This paper will examine three factors that are reducing the effectiveness of conventional military training and will propose an application of computer technology that promises to significantly improve the productivity of these training systems. The paper will first examine the factors of technology, manpower and money and their impact on todays technical training systems. It will explore the need to increase learner productivity and will finally describe the Marine Corps Communication-Electronics Schools Computer Based Education (CBE) System and how this system's application promises to increase the productivity of training systems in the face of changes brought about by the effects of technology, manpower and money.

Technology

Technology is reducing the effectiveness of current technical training systems. Technology, the application of scientific knowledge, is pervasive and is changing our world. Our engines of war have been strongly influenced by these changes. Gone are the days when the fighting of air battles could be controlled by information hand-lettered with grease pencils on plexiglas status boards in combat information centers. New high-speed enemy attack aircraft cannot be effectively countered except with the help of tactical

data systems that are able to detect, identify, track and engage these attack aircraft in seconds on computer controlled display panels. The advent of this vast influx of sophisticated military systems has created new training requirements that expand and change almost on a daily basis.

Every technological break-through in military hardware creates new threats to be countered. A review of the United States-Soviet Union arms race from the late 1940's to the present demonstrates the threat and subsequent counter-threat expansion of technology. Since the United States cannot hope to match the Soviet Union's numerical advantage in conventional weapons and nuclear missiles except by developing technologically sophisticated, multi-capability weapons systems ($123 Billion for Defense, 1979), emphasis on technological innovation will continue as an expressed national policy.

Although most new systems are improved versions of those currently in the active inventory, some are not product improvements. They create requirements for new operational and technical skills where none previously existed. For example, the Position Location and Reporting System (PLRS), being developed by the Army, will employ a sophisticated, computer supported system to provide accurate location and position information on friendly ground units and aircraft. This system replaces position location previously accomplished by map and compass, and puts technologically sophisticated equipment that must be maintained and operated by skilled personnel in units where this equipment previously did not exist.

As systems become more sophisticated and complex, they tend to become linked into larger systems. For example, the Marine Tactical Data System (MTDS) assists the air commander in the control of his assigned airspace, and in the detection, identification and engagement of a hostile airborne threat. This system links with the Navy Tactical Data System, NATO systems, etc., and becomes an integral part of the total air command and control system. Any component that becomes nonoperational reduces the capabilities of the total system. If a technician is improperly trained, and because of his lack of skill, puts a component out of action, his error will have a greater impact on the whole air command and control system than if the system was not linked and interdependent. Thus changing technology creates a requirement for more trained personnel possessing a greater array of skills. The training manager must teach these skills, produce more graduates possessing them and increase each graduate's proficiency in these skills.

Manpower

The second factor reducing the effectiveness of current technical training systems is manpower. Manpower applies to the students assigned to the schools and also the instructors and the managerial staff who operate the school.

The training manager must receive a certain quality and quantity of new students to achieve the required output of trained graduates. The quality of input will establish the amount of remedial training needed to bring the student to the minimum level of basic skills to proceed in the course of instruction with a reasonable chance for success. A poor quality input will increase course training time and the cost to produce the graduate. An insufficient quantity of input places pressure on the training manager to reduce attrition as the only means to meet graduate output goals.

The quality of the high school graduate who makes up the bulk of the input in technical training has been steadily declining. This reduction in quality is primarily in the areas of mathematics and verbal skills, the two most important basic skills that a technician must possess. Figures from the National Assessment of Educational Progress and the Ford Foundation indicate a continual downward trend in 1979 (Another "F" for American Schools, 1979).

The quantity of manpower available to the services is also declining. The armed services have operated without a draft since 1972. This requires an emphasis upon volunteer recruitment to maintain current strengths which is difficult considering that approximately 1,300 volunteers must be enlisted each working day to maintain the two million plus standing army (Recruiting Scandals, 1978). The qualification standards must remain high because as the armed services shift from a labor intensive force to a technology intensive force, less pick and shovel jobs are available. The impact of technology upon the armed services is also felt upon the private sector, and both the services and the private sector actively and aggressively compete for the small target

population. This target pool of highly qualified 17 and 18 year olds, to further complicate the problem, is shrinking steadily because of the end of the World War II baby boom. The application of demographics projects a volunteer pool of 2.2 million in 1979. By 1985, this pool will consist of less than 1.8 million (Volunteer Army Runs into Trouble, 1979). The recruiters will have to attract one out of every three eligible 17 and 18 year olds by 1985 to meet the strength requirements.

The changing manpower factor also impacts upon the training manager's staff. The instructors in a technical school are normally highly skilled senior operators or technicians who are required to fill supervisory billets in the field. As technology increases the number of these billets which must be filled to meet operational readiness requirements, the manager finds his instructional staff proportionately reduced. The trends facing the training manager are increasing need for quantity of technicians, each possessing greater skills, and reduced quality and quantity of new students. He must increase the training skill level to accommodate the advances in technology, increase the training time to allow for the remedial training in basic skills required by poorly qualified students, and reduce attrition to meet new graduation goals created by the expanded need for skilled technicians in the field and to compensate for reduced student input. He must provide these new and expanded training requirements with a reduced instructor staff.

Money

The third factor reducing the effectiveness of current technicial training systems is money. The training manager will have less money each year but will have greater operating expenses due to inflation and rising manpower costs. Current trends indicate that training dollars will be less available in the future. The fiscal year 1979 department of defense budget of training dollars decreased by 2.2 million from the previous fiscal year (Budget of the United States, 1978). Added to this loss in actual dollars is the additional loss of buying power of each dollar due to inflation. Inflation will have a significant impact on the ability of the training manager to duplicate the previous year's operation even if he receives the same amount of dollars.

The training systems are currently manpower intensive which means that the majority of the labor performed within the system is performed manually. Manpower costs are rising as salaries are increased to keep pace with rising inflation. In a system where the instructor is the prime means of instructional delivery, personnel pay raises increase the overhead costs of the instructional staff with no gain in productivity. Also, personnel pay raises increase the cost of extending training time because of the resulting higher cost in student pay and allowances which is chargable to training costs. Student pay and allowances alone accounted for 39% of the fiscal year 1978 training budget (MMTR, 1977).

Finally, the training manager is faced with an expanded man-hour investment for the development of training courses. Recently, the department of defense adopted the Instructional Systems Development (ISD) system. This ISD system is essentially a "cookbook" approach to the development of courses of instruction and is being implemented in the formal technical training schools. It requires an expanded dedication of manpower resources to course development and represents a significant additional manpower cost to the training manager.

Monetary trends indicate that the training manager will have fewer training dollars, the dollars he does receive will have less buying power, and the introduction of the ISD system will cost him some of those dollars without an immediate increase in productivity.

The efficiency and effectiveness of contemporary training systems is being degraded by the impact of technology, manpower and money. The training manager must be able to expand the variety, complexity and depth of knowledge of his courses of instruction to provide the skills required by the growing quantity and complexity of new military equipment being added to the services' inventory. He must also increase the length of his training pipeline to accommodate the remedial training required by the less qualified input student and to avoid increasing his attrition. He must accomplish all of this with a reduced training staff and an increasingly austere training budget. This represents the challenge for the training manager to overcome.

A Quantum Leap Forward

As Dr. C. Victor Bunderson, an emminent instructional scientist, so aptly stated, "people tend to create 'titanium horseshoes' when the real need lies in the creation of an automobile" (Bunderson, 1979). In other words, people often spend time making improvements on systems that are in themselves obsolete. He proposes that the instructional delivery system has reached its maximum efficiency and cannot be further improved without a "quantum leap". Instead of attempting to wring a small amount of increased productivity out of the conventional instructor-led, lock-step system of training where the instructor is the focus of instructional delivery, the delivery system must be changed by a quantum leap forward. This leap forward can be accomplished by shifting the burden of learning from the instructor to the student.

Current instructional delivery systems emphasize the instructor as the person responsible for the active role in teaching. The learner assumes the passive or receiver role. Emphasis on increased instructional productivity has focused upon improving the instructor's performance. Educational technology applications such as training films, instructional television, audiovisual devices, and training aids still depend upon the instructor to carry the burden of the teaching task.

Research into educational psychology and learning theory suggests two basic aspects of learning behavior. First, individuals learn at different speeds. We are all familiar with the fact that there are slow and fast learners, yet most of our conventional instruction is time dependent. Our courses are fixed in length and the learners are taught at an average speed, leaving the rapid learners hopelessly bored and the slow learners hopelessly lost. Our evaluation of learning mastery is accomplished by measuring the percentage of material the student retained within the alloted course time. This system is inefficient and results in both high attrition and graduates being sent to the field without full mastery of required skills. The second basic aspect of learning behavior is that individuals respond differently to different styles of instructional presentation. Learners possessing well developed cognitive abilities and high verbal skills will respond better to verbal or written formats such as textbooks than learners who have a low verbal ability. Yet, the learner with low verbal ability can learn the same material if it is presented using graphics, animation or exploded diagrams. Our current instructional system presents one instructional format for all students assigned to a class without regard to the instructional styles that would be most productive for each learner.

The reason that traditional lock-step instruction is employed, traditions aside, is because of the inability of the system to adapt to the individual learner's different needs. It is difficult for the school to manually develop and execute large numbers of individualized learning prescriptions. However, if our training system is to increase its efficiency to meet the current and future requirements outlined in the beginning of this paper, a quantum leap forward must be made. This leap can be accomplished by using a computer based system to: (a) shift the burden of instruction from the instructor-lecturer to computer technology for both on-line (i.e., interacting with the computer) instruction as well as other off-line methods of individualized instruction (textbooks, programmed workbooks, etc.) with on-line testing; and (b) develop and monitor individualized learning prescriptions for each student. Computer technology allows the training system to conform to the learning needs of each student and will allow the student to proceed at his speed receiving instruction presented in the most productive format for the student. These are the key concepts that will increase the productivity of the training system. The learner will gain some control over his learning environment, and will be given the responsibility to actively participate in his own education. The role of the training system will be to direct the student to find his own level based upon initial screening and to then adjust the material presentation formats based upon the student's performance (Bunderson, 1979).

Computer Based Education

The ability of the training system to shift the burden of instruction from the instructor to technology, and to individualize the instruction to meet individual learner needs is possible with the employment of technology. This employment should focus upon the substitution of labor from manual to

machine supported activities. Just as the manual method of maintaining pay records by handwritten entries into individual paybooks has been replaced by the computer supported joint unified military pay system (JUMPS), the manual management tasks required to operate a training system must be streamlined. Computer based education (CBE) is a term that applies to the incorporation of computer technology to the management of and to the instructional delivery within a technical training system. CBE incorporates two subsets of educational computer technology application, computer managed instruction (CMI) and computer assisted or aided instruction (CAI). CMI addresses the use of computer support to assist in the management of a training system. CAI addresses the interactive presentation of instruction to the individual student by means of a teletypewriter or cathode ray tube (CRT), a television-type visual display terminal. In CAI, the student receives the instruction by teletypewriter or CRT and responds by means of a keyboard or other input device. The computer evaluates his response and then presents additional instruction or branches to remedial instruction. Computer based education encompasses both the management and interactive teaching applications of the computer.

The MCCES CBE System in Action

The Marine Corps Communication-Electronics Schools (MCCES) CBE training system will support the basic principles of the learning process where a stimulus is presented to the learner and he responds. His response is evaluated and if the appropriate behavior is demonstrated, the next stimulus is presented. If all learning tasks have been accomplished, the activity ceases. If the appropriate behavior is not demonstrated, additional stimuli are presented until the correct response is received (Rhode et al, 1970). The MCCES CBE system consists of six subsystems that interact with each other, all supported by a centralized computer training subsystem.

Training Subsystem

The MCCES CBE training subsystem will provide the ability to initially screen the incoming student through a series of diagnostic tests and an evaluation of test results already held within the student's file such as the results of the general classification testing battery (GCT), or armed services vocational aptitude battery (ASVAB). From this initial screening, an evaluation will be made as to the amount (if any) of remedial training that the individual student requires to allow him to meet the prescribed minimum skills levels for success in the assigned course of instruction. If remediation is required, this could be provided by on-line, self-paced instruction or off-line, programmed text instruction with on-line testing.

The instruction within the CBE training system can be tailored to the needs of each student since the computer can prescribe and daily monitor thousands of individual learning programs. The CBE system will allow a shift in training emphasis from the amount of learning accomplished within a fixed time period to achievement of criterion objectives in the minimum time. This system adapts to the learner's varied rate of learning speed, and ensures mastery of the subject matter. In current technical training systems, the fast learner must remain in the course for the full scheduled time. The slow learner must hope to achieve the minimum knowledge in the scheduled time. In the MCCES CBE system, the learner exits the course upon achievement (i.e., mastery) of all learning objectives. Time savings in a military course of instruction is important because students in a training pipeline represent overhead costs to the services. A maximum of over 52% reduction in training time can be predicated with the application of CBE self-paced training (Survey and Analysis of Computer Based Training Systems, 1977). Speed and mastery are both assured by the delivery of only the needed instruction as determined by pre- and post-instructional testing.

The differences in the students' learning styles are detected during initial screening and a prediction is developed by the computer based upon comparison with previous student performances. The prediction prescribes the student's initial learning format. Dynamic monitoring of the student's progress develops feedback used by the computer to develop new learning prescriptions. In this manner the training media and materials are adapted to the student's learning needs rather than forcing the student to adapt to one presentation style.

The training subsystem receives primary emphasis because it represents the production subsystem of the train-

ing school. To support this training subsystem are several more subsystems that provide management information and actions that support school operations. These will be briefly discussed to show how they fit into the CBE system.

Resource Allocation Subsystem

This subsystem manages the accountability of the test equipment, training devices and simulators, etc., assigned to the school. It assigns use of these training resources based upon student loading and training needs. It identifies optimum times to conduct routine maintenance of this equipment based on student usage requirements and indicates equipment operational status to allow the training subsystem to schedule alternative training resources if primary training devices are being used or are inoperable. This subsystem also develops cost effectiveness and utilization data and compiles reports for training managers and higher headquarters.

Student Management Subsystem

This subsystem registers students on the system upon their arrival at the school. It assigns housing, tracks student locations during school hours, and interfaces with current military personnel management systems for pay, promotion, transfer, etc.

Courseware Development Subsystem

This subsystem allows on-line courseware development, and modification. It provides cataloging, indexing, and management of development materials required by the instructional systems development procedures. It has on-line authoring aids to assist the school staff in the modification of existing courses or the development of new courses.

Instructor Evaluation and Staff Management Subsystems

These subsystems assist the training manager in the management of his permanent school staff and instructors. They are primarily devoted to routine records keeping and interface with current military personnel management systems.

Improving System Productivity

The application of computer technology in the form of CBE will allow the training manager to improve the productivity of the training system. The courseware development subsystem will allow the school the flexiability to change courseware rapidly and efficiently to meet the changes in equipment and training requirements brought about by technology. By orienting the training system to the needs of the learner, the training manager can increase the output of graduates and reduce the training pipeline and the attrition rate. The manager can also shift the majority of the burden of instruction from the instructors to the technology. Finally, the cost of operations can be reduced by effectively managing training resources with computer assistance and the size of the support staff can be reduced by shifting routine, manual tasks such as records keeping, student registration, maintenance of academic files, etc., from the clerks to the computer. The computer is not a panacea to resolve all of the problems facing the technical training system manager of today, but it is a powerful tool that, when properly employed with skill and imagination, can achieve the quantum leap forward that is needed for the future.

Conclusion

In summary, the contemporary training systems using conventionally managed lock-step instruction are unable to adapt to the current changes in the environment without an unacceptable loss in productivity or increase in resource requirements. A major advance is needed in both the presentation of instruction and the management of the instructional system. This advance is the change of instructional delivery to an individualized instructional system with the burden of delivery placed upon technology. The MCCES CBE system is a technology based instructional delivery and management system that creates individualized learning prescriptions required by individualized instruction and manages the execution of this instruction. The use of the MCCES CBE system allows the students to become more actively involved in their own education. The CBE system is more responsive to the changes in the environment brought about by the impact of technology, manpower, and money and promises to ensure the efficient accomplishment of the training mission well into the future in spite of these changes.

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CREATING GRAPHIC DISPLAYS ON NON-GRAPHICS TERMINALS

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ABSTRACT

Graphic displays are an important tool for helping students visualize concepts presented by computer-based training materials. Many current terminals have limited graphic capabilities, but very few have complementary firmware or software to make those capabilities easily accessible to the instructional programmer. One solution to this problem is presented in this paper. An interactive system for creating graphic displays is described, and its use by Digital's Computer-Based Course Development Group is discussed.

The Problem

Digital Equipment Corporation's Computer-Based Course Development Group is developing a computer-assisted instruction (CAI) course that must run on two different types of video terminals: the VT52, which is in wide use among DEC customers, and the newer VT100, which has more sophisticated display capabilities. Neither of these is a full "graphics terminal". However, the course designers wished to use some fairly extensive graphics, including direct cursor addressing, the drawing of boxes, blocks of text, animation of text, and complicated erasing and refreshing of selected portions of the screen. To make programming of these functions easier, we developed a simple tool for creating graphic displays.

NOTE

This tool is not a "product" of Digital Equipment Corporation and is not available for sale. It is simply a technique for creating graphic displays on non-graphic terminals.

Both the VT52 and VT100 terminals can perform the above actions by means of "escape sequences", which are streams of ASCII characters preceded by the ESCape character (decimal character number 27 in the ASCII character set). When the computer initiates an escape sequence, for instance, by executing a special PRINT statement in a BASIC program, the terminal will take the action specified rather than printing the characters in the escape sequence on the screen. For example, escape sequences can be used to move the cursor to a specified location, erase part or all of the screen, and print special graphics characters.

Every special action has a unique escape sequence, and these may vary from one terminal to another. On the VT52 for example, the escape sequence to place the cursor at the 10th row and 15th column is

Ⓢ Y)-

where Ⓢ denotes the escape character. On the VT100, which adheres to the ANSI standard escape sequences, the same result is accomplished by the escape sequence

Ⓢ [10;15H

The VT100 also has capabilities that the VT52 lacks, such as bold and blinking characters, double height and double width lines, and reverse video.

Producing the instruction required on both terminals by coding the text and escape sequences into the instructional program is like trying to program in three languages simultaneously: the authoring language, VT52 escape sequences, and VT100 escape sequences. Also, CAI programs require huge amounts of text and graphics to explain and demonstrate the subject matter. The space that a single program can use is limited in any computer, but especially so on mini- and microcomputers. If highly graphic CAI programs are required to run on small machines, the instruction must be broken down into literally dozens of programs just to make them fit into the memory available. The control of these programs is complex, but more importantly from our point of view, passing control from one program to another takes an unacceptable period of time, leading to student dissatisfaction with the product.

Our Solution

We needed a tool that course developers could use to develop the displays needed to present a concept without requiring extensive training and the memorization of escape sequences. Our solution was to create a set of interpretive programs called DRAW. These programs incorporate high-level commands which are translated into the appropriate escape sequences. The commands are comparatively simple to remember, so the course developers can concentrate on the instructional value of various displays rather than the difficulty in programming them. Sample commands are shown in Table 1.

Since each terminal has different characteristics, the VT52 graphics editor simulates actions on the VT52 that may be primitives on the VT100 whenever possible. For example, the VT100 has an escape sequence to erase from the beginning of a line to the current cursor position. This primitive does not exist on the VT52, but the action is simulated by printing spaces from the beginning of the line to the current cursor position. The VT52 action is slower, but it produces the same result. The important point is that both the VT100 and the VT52 actions are initiated by a command of the form

.ebl (R,C)

which erases from row R column 1 to row R column C. Commands that are specific to the VT100 and that cannot be simulated, such as ".ron" to turn reverse video mode on, are simply ignored by the VT52 editor.

Table 1

SAMPLE DRAW COMMANDS

Command	Action
.at (12,26)	position the cursor at line 12 column 26
.cen (24,40) DRAW	center the "DRAW" on line 24 around column 40
.box (10,12)(18,52)	draw a box with its upper left corner at line 10 column 12 and its lower right corner at line 18 column 52
.lin (5,4,35,r)	draw a line that extends from line 5 column 4, 35 spaces to the right
.ani "DRAW" (15,6,12,ur)	animate the word "DRAW" by moving it from row 15 column 6, 12 spaces up and to the right
.txb (8,20)	begin a text block at row 8 column 20 (the first text line that follows will begin at row 8 column 20, the second one at row 9 column 20, the third at row 10 column 20, etc., until another DRAW command is encountered)
.ron	turn reverse video mode on (all succeeding characters printed will be displayed as dark characters on a light background
.rof	turn reverse video mode off

The DRAW approach to creating graphic displays has another advantage: the graphics information is stored separately from the CAI control programs. This allows the instructional programs to be smaller, and allows more program space to be devoted to complex answer judging and routing.

The Evolution of Graphics Displays

Creating graphics command source files. Graphic displays may be built with an interactive graphics editor, or files of graphic commands may be created with the normal system text editor. We have a different graphics editor for every terminal type that we use. All of these editors use the same command set, the same syntax, and accept the same graphic command source files as input. The only difference (as far as the course developers are concerned) is the type of terminal on which the editor is being used.

The output of the graphics editors are graphics command source files. These files contain the source code of the DRAW system displays, and are completely compatible between all graphic editors. That is, any source file may be processed by any editor, regardless of whether it was created using that editor. As mentioned previously, some DRAW commands may be simulated or even ignored if they are

not applicable to the terminal currently being used, but these commands will not generate errors and will not be deleted from the source code.

The source files consist of both DRAW commands and text. All DRAW commands start with a period as the first character on the line. All other lines are interpreted as text and are simply plotted on the screen at the current cursor position. Thus, a source file might consist of the following:

```
.box (3,15)(5,23)
.at (4,17) DRW52
.box (7,14)(9,23)
.at (8,16) DRW100
.ron
.txb (11,11)
 Interactive
    Graphics
     Editors
.rof
```

This source file would generate a display similar to that shown in Figure 1.

Source files are named according to the convention counnn.FRM. "cou" denotes a three-letter course code. For our project we have chosen the name EDT. "nnn" is the number of the display, from 000 to 999. ".FRM" is a fixed file extension used for all graphics command source files.

The graphics editors are highly interactive. When DRAW commands or text lines are entered, these actions cause immediate change on the user's screen. The editors also provide three types of editing commands:

- character and line mode editing commands such as @INSERT, @REPLACE, and @SUBSTITUTE),
- file manipulation commands such as @OLD, @NEW, and @SAVE, and
- graphics manipulation commands such as @MOVE and @REPLOT.

The editing commands are differentiated from DRAW commands and text lines by the presence of an @ sign as their first character. Using the editing commands, graphics command source files can be read into memory, edited, executed, and saved as the course developer desires. The course developer can list and execute all or part of any display desired, edit the display, and then list or execute the result.

```
+-------+
| DRW52 |
+-------+

+--------+
| DRW100 |
+--------+

Interactive
   Graphics
    Editors
```

Figure 1

DISPLAY GENERATED FROM
SAMPLE GRAPHICS COMMAND SOURCE FILE

Translating graphics command source files. When the the final versions of the graphics command source files are created, they are submitted to the graphics translators. The translators compile the source files into ASCII streams which are stored in random access files on disk. Like the graphics editors, there is a translator program for each type of terminal.

The translators are very similar in principle to the graphics editors, but instead of presenting the effects of each command on the screen, the translators store them on disk for later access. The ASCII streams created by the translators contain all of the escape sequences necessary to perform the actions specified in the graphics command source files.

The translator programs produce two types of random access files:

- library files, which contain the ASCII streams that actually format the screen and display the graphic data, and
- key files, which provide numeric indices to the library files, indicating the starting and ending record numbers for each display.

There is one library file and one key file for each type of terminal in the system.

The relationships between all of the steps discussed thus far is shown in Figure 2.

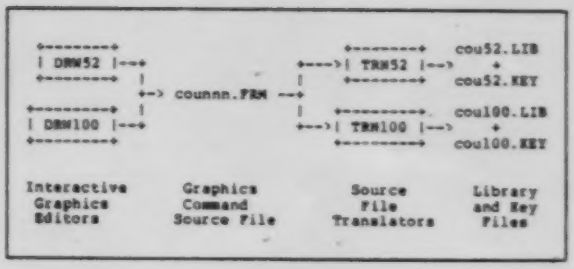

Figure 2

THE EVOLUTION OF GRAPHICS DISPLAYS

Calling Graphics Displays from Instructional Programs

The instructional control programs determine what type of terminal the student in running on at this moment, and access the corresponding random access files produced by the translators. In this way, the instructional lessons do not have to change for each terminal type on the system; they simply access the proper library and key files.

Presentation of each display is accomplished by a modular subprogram that is simply inserted into the instructional control program. The subroutine is called by the instructional lesson, with the number of a library display to be placed on the student's screen. This number corresponds to the number of a graphics command source file. For example, if the source file to be displayed is EDT123.FRM, the number passed to the graphics subroutine is 123. This calling number is used to reference the key file and look up the starting and ending record numbers of the display in the library file. The graphics subroutine then simply prints the appropriate records from the library file, and the display is shown to the student. This interaction is shown graphically in Figure 3.

The DRAW System

The DRAW system is currently being used by Digital's Computer-Based Course Development Group to produce a CAI course on the DEC Standard Editor, EDT. We have found that using it enables the course developers to bring up complex displays quickly and easily, and enables the instructional programs to be devoted to more complex feedback and personalization of instruction.

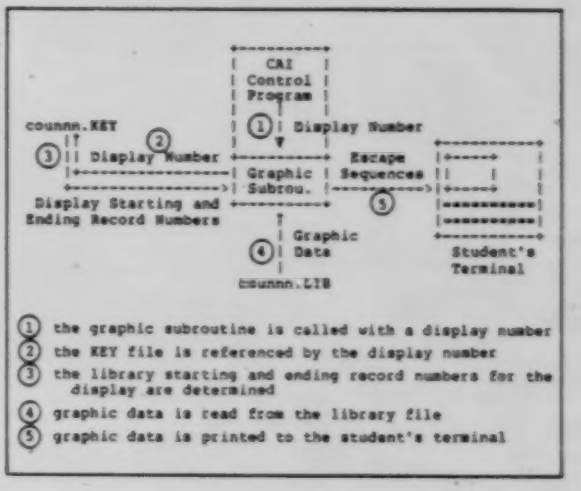

Figure 3

CALLING GRAPHICS DISPLAYS FROM INSTRUCTIONAL PROGRAMS

POLITICAL SCIENCE EMERGES FROM THE CAVE*

(Computer Augmented Video Education)

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ABSTRACT

Educational television and computers have both emerged as potential methods of increasing the efficiency and quality of learning. This paper discusses a method of joining the two technologies. The substance of the learning project presented happens to be political science, but the method has applicability over a wide range of substantive areas.

Discussions of teaching innovations tend to approach one of two extremes. One extreme, an innovator discusses his individual approach and attempts to make broad generalizations as to its applicability to the whole spectrum of substantive areas and to the broadest range of potential students. On the other extreme, the innovator discusses in detail his application focusing on its idiosyncracies and unique applications.

This paper will take a middle ground by discussing the applicability of CAI (Computer Assisted Instruction) for the social sciences, presenting a general CAI approach and outlining two specific applications in political science.

COMPUTER ASSISTED INSTRUCTION

Computer Assisted Instruction comes in many varieties. One approach is to have the student "play" the machine in a simulated experience (Coombs, 1976). The student is given a situation and can try out various strategies for reaching a goal. After a strategy is chosen the student is given feedback on the consequences of his choices. The student has a direct experience with a model and data which lead him to findings that are less effectively taught through more didactic methods (Masters, 1976, p. 86). This approach emphasizes analysis rather than the learning of substantive facts.

A second approach is to use the computer for student originated data analysis. Students are guided through progressively more sophisticated analysis ending up with potentially original research (see the S.E.T.U.P.S. Supplementary Empirical Teaching Units in Political Science, published by the American Political Science Association).

Most CAI involves some form of automated programmed learning which is either made more efficient or embellished through the use of the computer. Students are given a series of questions from a bank stored in the computer. After choosing a response they are branched to more difficult questions, or they are given remedial work, depending on their mastery of the material. The goal is to teach substantive facts and to prepare the student for the next level of learning. "Programmed instruction (which may or may not be administered by computer) focuses more directly on specific concepts or propositions that the student is expected to learn," (Masters, 1976, p. 86) rather than on experiences with data and/or analysis.

THE APPLICABILITY OF CAI TO SOCIAL SCIENCE LEARNING GOALS

Many political scientists (and social scientists in general) have been somewhat hesitant to use CAI, since they feel it does not match the educational goals nor the state of their discipline. Social scientists as opposed to "hard" scientists teach skills of analysis, interpretation and communication more than mastery of a fixed body of knowledge. Most CAI applications facilitate learning facts through drill and practice. The more one is dealing with interpretation and/or probabilistic answers, the less CAI will contribute.

While attempts are being made to expand the analytical uses of CAI (Coombs, 1976), social scientists don't have to sit back and wait. Every discipline includes some factual material which must be mastered before interpretation and analysis begin. A student can't critically analyze political philosophy before he knows which philosophers took which positions (Masters, 1976, p. 83). Students of Congress must know the rules, procedures and structures of the legislature before they can discuss the policy process. Students confronted with data must know how to read tables, charts and graphs before they can legitimately use that data to interpret a phenomenon. Limited mastery of the facts serves as a poor foundation for going beyond the facts to higher levels of analysis. While awaiting CAI methods which fit more closely the ultimate goals of social scientists, we can use CAI to more effectively teach the necessary factual material which many social scientists skip over (often naively expecting it to be picked up from a few assigned chapters in a basic text) while they reserve their attention and class time for the "more interesting stuff." If CAI can effectively and efficiently impart this information, thus freeing the teacher from more creative endeavors with a set of better prepared students, little further justification is necessary.

WHY USE CAI IN THE FIRST PLACE

The reasons for using CAI in the social sciences are similar to those outlined for using it in other realms: (see Pool, 1976, p. 2 and passim)

1) Efficiency: once prepared, a CAI program can be used with a large number of students while each time costing less per student.
2) Teaching is made more uniform: All participants in a CAI program are exposed to the same material presented identically.
3) Student involvement: Students are actively involved in learning and get immediate feedback evaluating their mastery of the material. The hard sciences with their laboratories encourage daily preparation. The rhythm of student work in the typical social science course is much less productive:
   "students typically read at an uneven rate. To be frank, one very normal pattern is a day or two of hurried reading before the midterm exam, an all night exercise in writing a term paper, and a couple of days of frantic study before the final examination. In this type of course, class meetings provide an inefficient means of diffusing information and a minimal sense of continuity between the spurts of attention and energy required of the student." (Masters, 1976, p. 88).
4) Individualization: students proceed through a CAI program at their own pace. The program can be tailored to reflect their unique strengths and weaknesses.

THE CAVE APPROACH TO LEARNING
(Computer Augmented Video Education)

CAVE is an offshoot of the more general computer supported instruction system at the U.S. Naval Academy (Pollak and Schwab, 1978 and Pollak, 1978) which combines educational television and CAI. With this system a computerized programmed learning component is integrated with video tape segments which can include substantive preparatory information, help sequences, visual material for analysis and anyother information which can be video taped. A control box[1] run by the computer automatically transfers the student from the computer display of information on a CRT screen to pre-selected video tape segments. Students may be routed sequentially through the video material or can be sent back to previous segments as well.

THE COMPUTER COMPONENT

The computer component of CAVE is a sophisticated drill/practice/tutorial system with a great deal of flexibility which includes the following components;

1) Student Stimulis: students are presented with questions via a CRT terminal. All students can be presented exactly the same set of question (fixed form) or each student can get the same basic questions with variations in the values for the variables within each question (item form).

Examples:

Fixed Form
What constitutes a majority in the House of Representatives if everyone were present?

Item Form
Student 1 - What constitutes a majority in the House of Representatives if everyone were present?
Student 2 - What constitutes a majority in the Senate if everyone were present?

2) Student response: students can be asked to respond from a list of multiple choice answers or enter the answer free form by typing it onto the CRT.
3) Analysis of student responses: responses can be evaluated looking for an exact answer, a specified range for numeric answers or by searching for a specific or an alternative set of keywords.
4) Student Feedback: students answering correctly receive a congratulatory message. With a wrong answer, several alternatives are possible. The author can specify the number of attempts allowed for each question and what is to happen after each attempt. The student can be informed he is wrong and asked to try again. A general help sequence can be presented. Appropriate diagnostic messages can appear after specified predictable wrong answers or the correct answer can simply be displayed. These messages and help sequences can be presented in written form on the CRT, or can be part of a video tape segment. After any incorrect answer the student can be routed to other sets of questions for remedial drill. After a predetermined number of wrong answers, the student can be terminated and sent back for further reading, review, and/or consultation.
5) Instructor Feedback: The instructor gets a user summary indicating time spent on the exercise, a quantitative analysis of attempts at questions and responses and optional student comments from the users. These user statistics can lead to pinpointing problem questions and common mistakes for a group of students or can serve as the basis for grading individual students.

While some of the above tasks could be accomplished by a programmed learning text, the computerized automation adds some new dimensions such as:

- More complex routing of students is possible.
- The student can focus on the substance of the lesson and not spend an inordinate amount of time routing himself.
- The student gets immediate feedback.
- The possibility of cheating by looking ahead at answers is removed.
- The computer can analyze answers in a more complex way.
- The computer keeps an accurate record of all student actions in a way almost impossible if being done by hand.
- For many students the "aura of the machine" is a motivational lure which can be capitalized on. Since we are more interested in learning than in experimental results, a creative use of the "Hawthorne Effect" is appropriate. (see Pool, 1976, p. 28).

THE AUDIO-VIDEO COMPONENT

The use of television for learning has often meant taping lectures for the sake of convenience and imposing on students a second best copy of the live performance. Evidence indicates that the live lecture is vastly superior to the pre-recorded one (Masters, 1976, p. 100). While creative use of television in the classroom is possible (see Frantzich, 1976, passim), the temptation to do old things in new and inappropriate ways often wins out.

Inappropriate applications of a new technology does not mean we should "throw the baby out with the bathwater." Television can impart information to students in a way impossible or more limited on a written page or on a CRT terminal. In presenting visual material, the camera can focus in on particular aspects of a visual display and force attention to that limited aspect. On television, one can use real world visual examples with move-

ment, color and variety not possible by other means. By presenting material both orally and visually a useful redundancy reinforces learning.

Although pre-recorded lectures are inferior to live ones, they are often superior to the written page in imparting information. When used judiciously with appropriate interactive follow-up, television lecture segments can be quite effective. When combined with the computer, the weaknesses of television alone can be overcome and the effectiveness of CAI enhanced.

The weakness of television alone is simply the magnification of weakness of lectures in isolation. There is no guarantee in presenting a lecture that students will be motivated to absorb the material nor do the student or instructor have any immediate feedback on what is being absorbed. With small classes, the Socratic method of constant questioning and answering, or very frequent quizzes can serve to motivate and assess progress, but this is often impossible. By combining mini-television lectures surfeit with active visual components and immediate active use of the information presented, motivation to absorb the information is enhanced and the assessment of progress is possible. Under such a system even students in large classes do not have to be passive consumers of information, but can move into the more educational active participant mode tailored to their learning speed.

In creating the television component it became clear that current students come from the "boob tube generation" of sophisticated television consumers. Care must be taken so that programs resemble professional productions more than home movies, or else students as critical consumers will focus more on the style than the content.

In some courses CAVE programs can be used not only to tailor the speed of presentation but also tailor usage to substantive needs. Not every student in every course need be confronted with the same substantive material. A student can specialize within a course without taking up class time or over burdening the instructor. A student can be sent to a library of CAVE programs to fill in his educational gaps or to lead him on to new endeavors. For example, a choice from a library of research methods CAVE programs might serve as the first step for students doing a research paper. Some students may choose to become qualified on survey research methods while others would seek out help in using government documents or existing data banks. Giving all students a brief introduction to each of these resources in a substantive (not a methodology) course would not be the most effective use of time. Being able to route students who will use the material immediately would be much more effective.

TWO CAVE APPLICATIONS IN POLITICAL SCIENCE

(1)A RESEARCH METHODS CAVE PROGRAM

As the social sciences become more empirical and deal with more and more data, students need to think in terms of relationships between variables and to become conversant with reading and interpreting tables which relate variables. This CAVE program was designed as a review drill for students in a research methods course who had covered the material in class and as a place to send selected students in other courses who needed upgrading of these skills.

The program consists of four mini-lectures (4-5 minutes) covering the following topics:

- thinking in terms of variables and relationships
- creating contingency tables
- interpreting two variables relationships
- controlling two variable relationships for a third variable

The video tape is used primarily to impart information concerning the conventions for creating contingency tables and strategies for interpreting them.

After each video segment, the student is automatically switched to a series of questions on the material just covered. In the early segments emphasis is on definitions (i.e. independent variable, dependent variable, table rows, table columns, etc.). Later students are given complete tables and asked to determine what can and can not be said from the data given.

Students choose their answer from a set of fixed alternatives. If correct they are given a random congratulatory message. If incorrect they are given either a written help sequence explaining why their answer was wrong, or they are automatically switched to the relevant portion of the original video type covering the missed material.

Although a strict experimental procedure was not used in evaluating this project, some conclusions are possible. Student reaction was quite positive with special commendation given to the self pacing aspect of the program. Students who had used previous CAVE programs requiring manual switching from the com-

puter to video components found the automatic switching far superior. Most criticisms dealt with the technical aspects of the program. Limitations on the number of lines on the CRT terminal meant that all data would not fit on the screen at one time and some handout sheets had to be employed. It also became clear that simplicity in getting on the system is a virtue. The more effort a student must expend on deciphering the system, the less effective learning takes place.

From an impressionistic faculty point of view, it was clear that students learned the material better. In later papers and assignments students did not make the obvious factual mistakes common in previous sections of the course. There was less dramatic improvement when it came to sharpening analytic skills, but improvement never the less.

As a program learning sequence, this CAVE program was certainly a success. To convert it into a quiz mode to be used in grading, the fixed format questions will have to be converted to a variable format in which each student gets different questions.

A LEGISLATIVE ROLE ANALYSIS CAVE PROGRAM

While the CAVE program for teaching about tables emphasized the learning of factual material, the CAVE program focusing on legislative roles currently under development will emphasize analysis and the application of social science theory.

Many analysts of the legislative process have discovered that legislators carry with them a perception as to what kind of behavior is expected of them (Davidson, 1968, p. 80). These role perceptions vary across individuals and stem from their personal and political backgrounds. Roles imply choices of behavior patterns when one receives conflicting demands, and one would expect persons with different role expectations to behave differently. For example, junior legislators with weak electoral strength see their purposive role as being a tribune (the reflection of popular will) as opposed to senior leaders with strong electoral bases who view themselves as "ritualists" (the internally oriented legislators who focus their efforts on making the chamber more productive rather than emphasizing representation). Other role categories have been discovered for a wide variety of demands. This CAVE exercise will review students' substantive knowledge of role theory, but more importantly will give them some experience in analysis and research strategy.

After reading the role theory literature, a CAI segment will drill them on role definitions and the hypothesized causes and consequences of role choices. Once their familiarity with role theory and its implications has been proved, they will be allowed to go on to more creative use of the material.

Via the video tape students will be introduced to ten selected congressmen, and asked to choose one to analyze. To simulate doing research under the conditions of limited resources, they will be allowed to choose four bits of data out of a list of twenty characteristics, some of which have been shown to be related to role choices, (data such as: party, marginality, seniority, leadership positions, etc.).

With their knowledge of role theory and the data in hand, the student will be asked to predict how their chosen congressman will answer a number of questions concerning role choices congressmen must make.

The feedback to the students' role prediction will be in the form of a video tape response by the congressman from a pre-recorded interview. Before assessing the correctness of their prediction the student will be asked to categorize the congressman's taped response in role terms. Students will have the option of rehearing the taped segment. Student predictions will then be related to the actual response and the student will receive an evaluatory message.

After each role prediction, students will be allowed to ask for one more piece of data on the member. If their prediction is at odds with the oral response they will be asked to write a brief discussions of why they were so wrong (i.e. weakness in the theory, too limited data, idiosyncratic member, etc.).

The above technique has been used successfully in a class setting (Frantzich, 1976), but has shown some weaknesses which the CAVE approach will help avoid. Students will have to make some research choices as to which data will be available. In the class setting predictions and analysis tend to be dominated by a few students. It is also common for a "groupthink" pattern to develop where some individuals just go along with the crowd. In this approach, everyone will be involved and forced to make analytical decisions. It is expected that some in-class analysis will be done in conjunction with the individualized CAI and that student responses to their errors in prediction will serve as the source of in-class discussion.

In-class use of the role prediction technique has also shown the importance of the video segment. The audio-video

presentation of the congressman's response not only holds the attention of students much better than was the case with written material or the audio alone, but it also sets the stage for placing the information in context. Watching a video taped response allows one to judge the forthrightness of the interview subject, the skill of the interviewer and the physical context in which the interview took place. Student impressions of the interview subject were greatly enhanced by seeing him in action during the class use of this material. This is likely to be even more important when an individual student can replay segments at will to receive more information.

This CAVE approach will allow the student to go significantly beyond the typical CAI exercise which stops at the learning of facts, and move into experiences in choosing data and opportunities for testing theories.

CONCLUSIONS

While no new teaching technology will be a panacea and none will do everything a capable teacher could do under optimal conditions, Computer Assisted Video Education (CAVE) provides a useful marriage of two technologies which promises to provide educational opportunities well beyond either of the approaches in isolation. In some cases CAVE programs with their ability to integrate audio-visual material and CAI will provide learning opportunities for individual students which surpasse that available in a group classroom setting. At this point the availability and potential of the technology is no longer in question. The more crucial test will involve creating the substance of the programs, challenging questions, insightful diagnostics of answers and meaningful opportunities for analysis. The creation of the printing press did not foreclose the printing of junk, nor does the availability of sophisitcated CAI technology reduce the possibility of inappropriate usage. Therein lies the challenge.

FOOTNOTES

[1]The switching mechanism was created by Professor Ralph Santoro, Electrical Engineering Department, U.S. Naval Academy in coordination with Dr. Richard Pollak, Associate Director for Educational Development at the Academic Computing Center at the U.S. Naval Academy. Dr. Pollak also played a major role in developing the CAVE sequences described.

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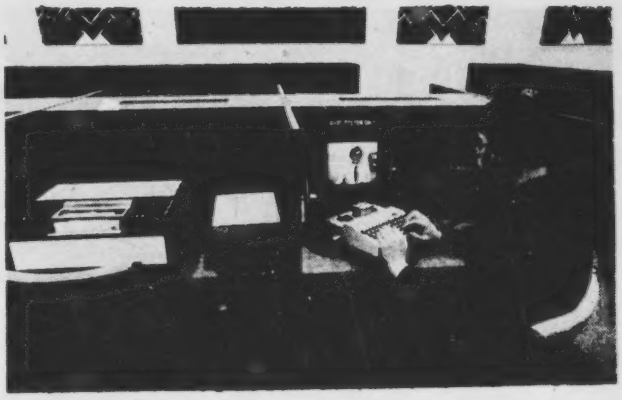

THE MICROCOMPUTER AS A COMMUNICATION DEVICE FOR NON-VOCAL CHILDREN WITH LIMITED MANUAL DEXTERITY

Bill Shirriff

Portage la Prairie School Division

Cerebral Palsy frequently results in lack of speech capability as well as in severely limited manual and finger dexterity. This physical limitation in some cases makes the operation of an electric typewriter impossible even with the use of a keyboard mask.

A student in our school system with limited manual dexterity as well as total absence of speech indicated the need for the following:

1. a means by which he could indicate answers more precisely than is possible through the use of a number or word board,

2. a means by which he could generate spontaneous sentences of greater complexity and more appropriate grammatical structure than is possible through the use of Bliss Symbolics,

3. a means by which spelling, reading, and other basic skills could be taught and monitored accurately.

Since the microcomputer is a relatively low cost and readily available device, student interfacing and programming techniques were developed to facilitate the use of the microcomputer as a communication device for use with children who have limited manual dexterity.

This paper discusses the use of the Radio Shack Level II TRS-80 and the 16K Commodore PET as being two of the microcomputers most commonly available to school systems.

STUDENT INTERFACING

Using a Masked Keyboard

A plastic mask covering the entire keyboard was constructed to facilitate the student's hand movement over the keys without accidental contact with extraneous keys. Holes were drilled through the plastic to allow access to a few keys, spaced as far apart as possible. Trial and error indicated that in the case of our student seven holes were the maximum that could be used without resulting in an excessive number of accidental key presses.

The six keys: "3", "7", ":", "S", "H", ";", and the space bar of the TRS-80 were changed to represent the numbers from one to seven under software control. Gummed labels were attached to the key tops to indicate the new function of the keys.

Using a Four-Position Joystick

Students with inadequate finger control to activate the keys of a keyboard could be interfaced to the computer using a four-position joystick such as is readily available for the Commodore PET using the instructions supplied with the joysticks. This would allow four choices: up, down, right and left.

PROGRAM EXAMPLES

Sentence Building

A selection of words and/or phrases was programmed into the computer as DATA statements. These words and phrases were organized with the first group being subject nouns, the second group verbs, and the third group object words .

The nouns are displayed on the screen six at a time with the seventh choice being to display additional choices within the same group. Pressing '7' causes the program to display the next six items in the same group, continuing the cycle back to the beginning until a choice is made.

Figure 1 illustrates the appearance of the screen at the beginning of the program.

```
1 - THE MAN
2 - THE GIRL
3 - THE BOY
4 - THE DOG
5 - THE HORSE
6 - THE COW

PRESS '7' FOR MORE
```

Figure 1: INITIAL SCREEN APPEARANCE

If none of the words displayed is appropriate, the student presses '7' to obtain other choices from the same group, as shown in Figure 2.

```
1 - SCHOOL
2 - MY TEACHER
3 - MY FRIEND
4 - MY MOTHER
5 - MY FATHER
6 - GEORGE

PRESS '7' FOR MORE
```

Figure 2: SCREEN AFTER PRESSING '7'

When a selection of one of the noun group is made, the word chosen is displayed at the top of the screen and six of the items from the verb group are displayed as shown in Figure 3.

```
GEORGE

1 - LIKES
2 - WANTS TO
3 - IS
4 - SAYS
5 - THINKS
6 - EATS

PRESS '7' FOR MORE
```

Figure 3: SCREEN AFTER PRESSING '6'

After selection of one of the verbs, the verb is printed at the top of the screen behind the noun, and six of the object statements are displayed. In each case the recycling feature allows the choice of one item from the group. After choosing a verb, the display would be as shown in Figure 4.

```
GEORGE IS

1 - SORRY
2 - NICE
3 - HAPPY
4 - SAD
5 - ANGRY
6 - FUN

PRESS '7' FOR MORE
```

Figure 4: SCREEN AFTER PRESSING '3'

The words and phrases in the computer memory are easily changed to correspond to the reading series and classroom activities by changing the content of the DATA statements. Generally a choice of twenty-four subject phrases, twelve verbs and forty-two object phrases was found to be manageable for our student. The number of phrases in each group would depend upon the age and reading level of the student.

Following the selection of an object phrase the sentence is displayed together with the command, "TO BEGIN AGAIN PRESS '7'" as shown in Figure 5. This display remains on the screen until key '7' is pressed, at which time the screen is cleared and the whole process begins again to produce a new sentence.

```
GEORGE IS SAD.


TO BEGIN AGAIN

PRESS '7'
```

Figure 5: SCREEN AFTER PRESSING '4'

Word and Sentence Building

To provide greater flexibility of output a program was designed which uses the seven keys in a manner similar to that used with phrases, except that each key press prints a single alphabetic character, a space, or a punctuation mark on the screen.

The initial screen display allows for the selection of the group containing the desired letter or function as shown in Figure 6. In this example the characters are grouped alphabetically for simplicity. However, other grouping arrangements may be more convenient for a different person. Experimentation with grouping the most commonly used letters together, or grouping vowels and consonants separately, is necessary to determine the best arrangement depending upon the age, experience and capabilities of the particular person using the system.

```
1 - A B C D E F
2 - G H I J K L
3 - M N O P Q R
4 - S T U V W X
5 - Y Z  SPACE . ? CLEAR
6 - END PROGRAM
7 - CORRECTION
```

Figure 6: INITIAL SCREEN DISPLAY

Choosing a group (for example,"3") results in a display enabling selection of a single character as in Figure 7.

```
1 - M
2 - N
3 - O
4 - P
5 - Q
6 - R

TYPE -7- TO CONTINUE
```

Figure 7: SCREEN AFTER PRESSING '3'

The character selected is printed at the top of the screen as in Figure 8, and the program goes back to the original screen display while retaining the selected letter on display at the top. The program is capable of printing three lines before requiring the screen to be cleared.

Provision has been made in the program to provide punctuation, spaces between words and a correction feature which allows the user to backspace in

order to remove the last letter or letters displayed.

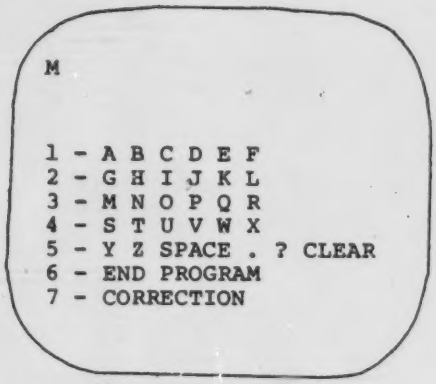

Figure 8: SCREEN AFTER PRESSING '1'

Using Four Choices

A four position joystick, or four switches operated by foot or by head-stick may be used for printing sentences. This would enable students who are lacking in hand control to operate the computer. In this case the program would display three choices with three letters in each, and a fourth choice to display another group of letters as shown in Figure 9.

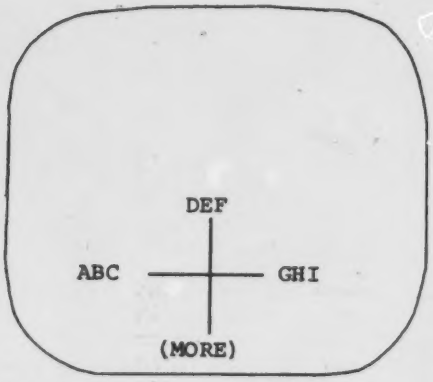

Figure 9: INITIAL SCREEN APPEARANCE

Pushing the joystick down would result in a different group of letters being displayed as in Figure 10.

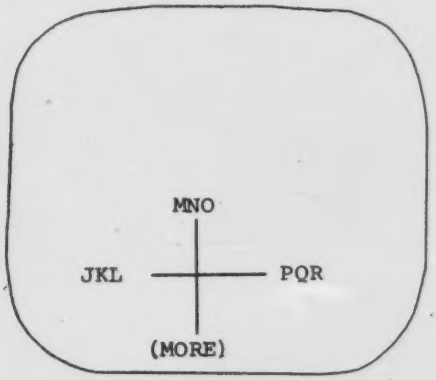

Figure 10: SCREEN AFTER PUSHING JOYSTICK DOWN

Pushing the joystick to the right would result in the selected group of letters being split into individual letters for final selection as in Figure 11.

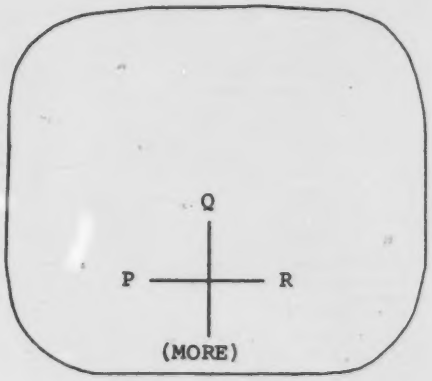

Figure 11: SCREEN AFTER PUSHING RIGHT

Again pushing to the right would result in the "R" being displayed as in Figure 12. The program would cycle back to the original display and the process would be repeated for the next letter to be printed.

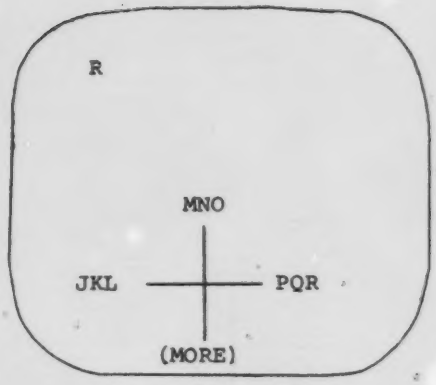

Figure 12: SCREEN AFTER PUSHING RIGHT

As in the previous program description punctuation, spacing and correction features would be included.

TECHNICAL DETAILS

Software Definition of the Keys

The following program lines accomplish the change in function for the keys being used as well as deactivating the other keys:

```
100  K$ = INKEY$       (or GET K$)
105  IF K$ = "" THEN 100
110  K = 2.7
115  R$(1) = "3"
120  R$(2) = "7"
125  R$(3) = ":"
130  R$(4) = "S"
135  R$(5) = "H"
140  R$(6) = ";"
150  R$(7) = " "
160  FOR I = 1 TO 7
165  IF K$ = R$(I) THEN K = I
170  NEXT I
175  IF K = 2.7 THEN 100
```

The above program utilizes "GET" for the Commodore PET or INKEY$ for the TRS-80 to avoid the necessity of pressing "RETURN". The fewer key presses required the less physically tiring the process will be. The line, "K = 2.7", assigns an arbitrary value to K to check for redefinition.

Avoidance of Multiple Entries

It may be necessary to disallow more than one keypress at a time since poor finger control often causes multiple presses when only one is intended. This may be accomplished by inserting the following lines just prior to the desired input:

```
85  Q$ = INKEY$      (or GET Q$)
90  IF Q$ <> "" THEN 85
```

The above lines will also eliminate the effect of keyboard "bounce" on the TRS-80.

Requirements for the Mask Construction

A sheet of plastic can be bent to form a satisfactory mask. This mask needs to be removable or hinged to allow access to the full keyboard for loading the programs.

Rigidity of the plastic mask is desirable but not essential since the software routine deactivates the unused keys with the exception of the 'BREAK' key. If the user's hand pressure on the mask activates the BREAK function then the key may be disabled on the TRS-80 Level II by: POKE 16396,23 (and re-enabled by POKE 16396,001). For the PET the 'STOP' key may be disabled by: POKE 144,49 (and re-enabled by POKE 144,46).

The finger holes in the mask need to be spaced far enough apart to avoid having more than one of the student's fingers pressing a key at one time.

PROGRAM AVAILABILITY

We are currently using the full 16K of user memory with a menu to select the particular activity to be done. The particular activities are: addition and subtraction of numbers from one to ten; teaching of ordinal numbers; filling in the blanks for sentences based on the reading series; and games of Wumpus Hunt and Paper, Rock, Scissors.

The computer has been used to obtain accurate responses to the Peabody Picture Vocabulary Test and the Peabody Individual Achievement Tests since both tests require selection of the correct answer from four possible choices. At present the author is adapting the Metropolitan Achievement Tests to be used with the microcomputer as the communication device.

Toward the goal of establishing a library and clearing-house of specialized software for use by physically handicapped and/or non-vocal students, the author welcomes information, ideas and modified software programs for either the TRS-80 or the Commodore PET.

Program listings or cassette copies of programs are available from the author at: P.O. Box 104, Portage la Prairie, Manitoba, Canada.

A TIME-SHARED, MINI-COMPUTER-BASED TUTORING SYSTEM FOR NON-PROGRAMMERS

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Robert M. Aiken, The University of Tennessee

ABSTRACT

A system of computer programs for providing computer assisted tutorial lessons is presented. The programs were developed on a PDP8e minicomputer with 20K, 12 bit words of memory, using a 1.6 million word disk and five teletypewriter terminals. The programs were written in the BASIC language and run under a time-shared BASIC interpreter. The system provides instructors with a means for easy authoring and editing of tutorial lessons. The lessons are administered to students at a terminal by means of a computer program. The tutoring system was determined to be useful as an adjunct to various teaching methods in a wide range of subject areas. Instructors and students with no expertise in computer programming are able to use the system without difficulty.

INTRODUCTION

In addition to the various computer-assisted instruction (CAI) systems which already exist, a system is needed which can be implemented on a minicomputer with minimum effort from educators and at minimal cost to the educational institution (see Bibliography). This paper presents one feasible approach to creating such a system. The system of programs developed here is based on tutorial lessons produced by the instructor, which are stored on disk for subsequent presentation to a student by way of an interactive computer terminal. The system is designed to operate under a time-shared BASIC interpreter, on a PDP8e minicomputer with 20K, 12 bit words of memory, using a 1.6 million word disk (see Figure 1).

Tests of the system demonstrate that both instructors and students can use it with no difficulty. The structure of the lessons allows for effective presentation of verbal as well as numerical tutorials in a manner which encourages the student to proceed at his own pace. The collection of programs and tutorial lessons can be distributed to institutions with similar hardware and software. This CAI package can thereby benefit a number of smaller educational institutions that are interested in implementing a CAI system.

THE STUTOR SYSTEM

The tutoring system we have produced is called STUTOR, an acronym for student tutor. Software for the system includes a BASIC interpreter, other utility programs, and tutoring system programs written in BASIC. The commercial software consists of OS8, an operating system for one user, and EDU25, a time-shared BASIC interpreter for up to eight users. Both of these are produced by Digital Equipment Corporation. The programs for the tutoring system and a modification of the EDU25 interpreter were produced at Carson-

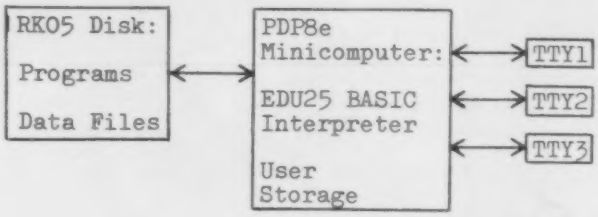

Figure 1. Computer System Configuration.

```
OLD STUTOR                                                  Go get tutoring program.

READY
RUN                                                         Run it.

WELCOME TO THE STUDENT TUTORING PROGRAM.

TYPE YOUR NAME, PLEASE? SAM B. JONES

ALL RIGHTY, SAM, WHICH LESSON DO YOU WANT? STUEXM           Ask for the example
                                                            lesson.
WHO IS THE AUTHOR OF THE STUTOR SYSTEM?
? SAM B. JONES                                              Sam types a wrong answer.
SAM, YOUR ANSWER IS NOT LIKE MINE.  TRY ANOTHER:
? HELP                                                      Sam asks for help.
NO (SIGH!), SAM!  THIS WILL REQUIRE MORE STUDY!

                                                            Sam is given a hint:
→ OK, SAM, I'LL GIVE YOU A HINT:  HE'S THE BALDEST ONE IN
  THE PHYSICS DEPARTMENT.  HIS NAME BEGINS WITH A 'B'.
  NOW, WHO IS HE?
  ? DR. BURTON                                              Sam's answer is partially
  OKAY, SAM, THAT'S BETTER!                                 correct.

                                                            The partially correct
THE MAN'S FULL NAME IS DR. JOHN W. BURTON, SAM!             answer is counted right,
                                                            and the full answer is
                                                            given to Sam.
HERE'S AN ARITHMETIC PROBLEM, SAM:

  54  + 47 = ?
? 91                                                        Sam misses the arithmetic.
SAM, YOUR ANSWER IS NOT LIKE MINE.  TRY ANOTHER:
? HELP                                                      He asks for help.
NO (SIGH!), SAM!  THIS WILL REQUIRE MORE STUDY!

  54  + 47  = 101                                           STUTOR shows him how to
                                                            do it right.
SHALL WE TRY THIS LESSON AGAIN, SAM?
? YES                                                       Sam asks to run this
                                                            lesson again.

WHO IS THE AUTHOR OF THE STUTOR SYSTEM?
? DR. JOHN W. BURTON, PHD.                                  Sam's answer is more than
I AGREE!!                                                   correct.

HERE'S AN ARITHMETIC PROBLEM, SAM:

  78  + 77 = ?
? 15-55                                                     Sam types an error and
CORRECT!  STUDY PAYS OFF, SAM!                              corrects it with the
                                                            rubout key.

                                                            STUTOR reports to Sam:
SAM, THIS HAS NOT BEEN A VERY GOOD LESSON.
YOU NEED TO STUDY SOME MORE AND TAKE THIS LESSON AGAIN.
OF 5 QUESTIONS, YOU HAVE ANSWERED ONLY 3 CORRECTLY, 3 AT FIRST TRY.
YOU MADE 4 INCORRECT RESPONSES.
YOUR SCORE WAS 60 %. SEE YOU LATER, SAM!!
```


Figure 2. Sample Tutoring Lesson Run by the STUTOR Program.

TABLE I

REINFORCEMENT CODES

Code	Reinforcement
-2	(No reinforcement. Question is counted correct.)
-1	(No reinforcement. Question is not counted at all.)
0 or R	(Automatic positive reinforcement, chosen at random from 1--4.)
1	THAT'S VERY GOOD 'NAME'!
2	CONGRATULATIONS, 'NAME'!! YOU ARE CORRECT.
3	YOU'RE IN THE GROOVE. KEEP UP THE GOOD WORK.
4	THAT'S CORRECT. I LIKE YOUR STYLE, 'NAME'!
5	WELL, 'NAME', YOU FINALLY GOT IT!
6	THAT'S NOT ONE OF MY ANSWERS, 'NAME'. TRY ANOTHER:
7	NO, 'NAME', TRY AGAIN.
8	NOPE. TRY ONCE MORE.
9	'NAME' THAT'S NOT VERY GOOD! PLEASE STUDY THIS SOME MORE.
10	THIS CALLS FOR REMEDIAL ACTION! LET'S TRY SOMETHING ELSE.
11	(Automatic negative reinforcement sequence, numbers 6--9.)
12	(No reinforcement. Question is counted incorrect.)

Newman College (Burton, 1978). The modification to EDU25 allows interchangeable access to both protected and unprotected files.

Two STUTOR system programs, AUTHOR and EDITOR, provide for creating and editing tutorial lessons. These lessons are stored as data files containing text, questions, instructor's answers, and other specifications. These data files are used by a program called STUTOR to administer a tutoring session to a student via one of the interactive terminals.

To engage in a tutoring session, a student runs the program called STUTOR, as illustrated in Figure 2. The lesson consists of a series of frames, each containing some text-question material, followed by a reply from the student. The student's name, randomly selected numerical values, or computed constants may be included as a part of the text. The numerical values may be used by the instructor in constructing the correct answer to a problem.

The student's answer may be either verbal or numerical as designated by the instructor. A multiple-choice answer is equivalent to a single-character verbal answer. The instructor may allow some latitude in either verbal or numerical answers by using the wild card characters, "#" and "?". For example "CHAR#" would match any character string beginning with "CHAR" (e.g. CHARLES, CHARACTER, etc). STUTOR selects an appropriate response to the student's answer from a set of built-in positive and negative reinforcement sentences. A typical set of these responses is shown in Table I. The instructor may also construct his own responses.

The sequence of frames presented to the student is a function of the student's replies and the lesson design. For example, further instruction may be presented in response to an incorrect reply, as shown in line 12 (at the ⟶) of figure 2. Sequencing of tutorial material may also depend upon the number of correct or incorrect student replies. The student may terminate a lesson prematurely by entering a reply of "END."

At the end of a tutoring session the STUTOR program prints a report to the student, evaluating his performance during the session, as illustrated in the last five lines of Figure 2. The report includes the student's score, which consists of the quotient of the total correct answer credits divided by the number of questions. One of three different closing remarks is printed, depending on how well the student performed.

A flowchart is provided in Figure 3 which illustrates the process of producing a lesson. Programs used in this process include AUTHOR, LISTOR, EDITOR and TESTOR. AUTHOR is used for entering the lesson into the system as well as for inserting and deleting entire frames. Figure 4 illustrates the use of AUTHOR to create the

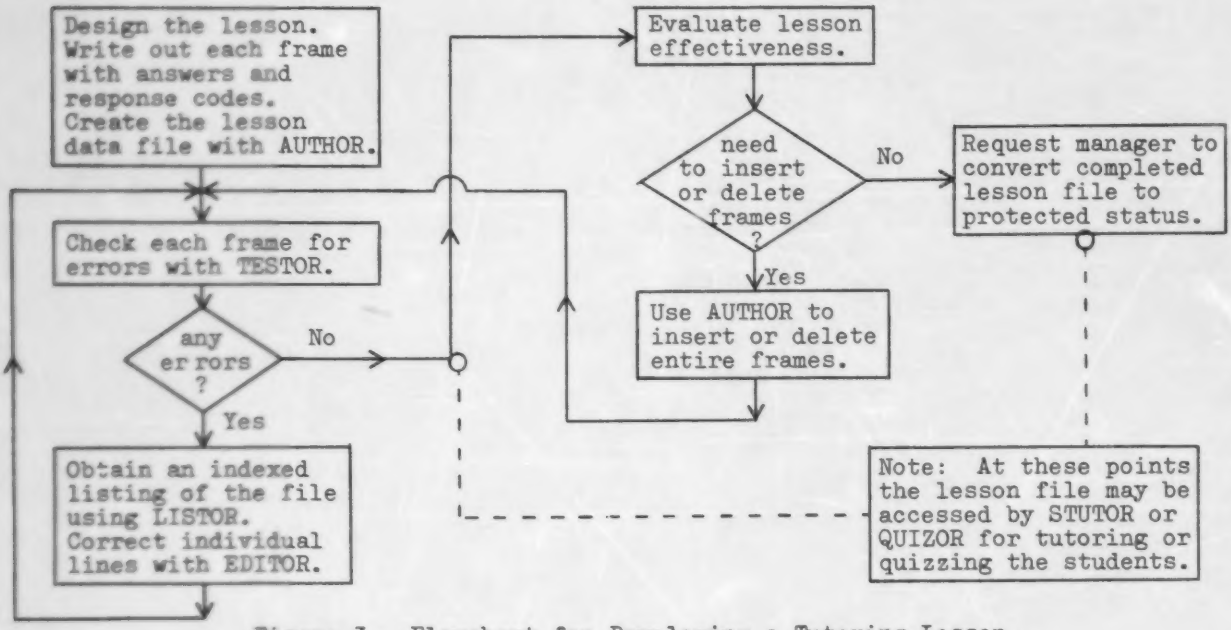

Figure 3. Flowchart for Developing a Tutoring Lesson.

lesson shown in Figure 2. The LISTOR program is used to obtain a listing of a lesson data file, indexed by frame number and line number. A sample output from LISTOR is shown in Figure 5. The EDITOR program is used to replace a line within a frame with one or more corrected lines. TESTOR is used to check the syntax of any portion of a lesson data file.

A group of lessons may be printed in the form of an examination by a program called QUIZOR. The format is usually satisfactory for reproducing an examination for a class, or for administering a quiz to an individual student. QUIZOR also prints a key for the instructor.

EVALUATION OF THE STUTOR SYSTEM

The STUTOR system has been tested in three courses at Carson-Newman College. The System received a preliminary test in a general physics course in the Fall of 1976 and was used extensively in the same course in the Fall of 1977. In addition, tutoring lessons have been included as part of a self-paced course in remedial mathematics for college freshmen (two separate classes), and tutoring for examinations has been provided in a course in elementary physics for non-science majors. With some additions and modifications these materials continue to be used.

Evaluation of the performance of the tutoring lessons was provided in part by statistical data gathered by the computer at the end of each session. Other evidence was provided by anecdotal data obtained from questionnaires completed by students in each of the three courses and by comments obtained from the professors. The results from the evaluations by the students are compiled in Tables II and III. They provide no conclusive results concerning the value of the tutoring system, but the general attitude toward the lessons was favorable. From the data comparisons may be made between lessons.

In Table II the statistical data produced by the system are summarized. Totals and averages are presented regarding the lessons in each of the four classes, and for all lessons together. To indicate the range of values the last two columns tabulate the minimum and maximum values encountered for individual lessons (excluding some which were not statistically significant).

The conclusions drawn from Table II may be summarized as follows:

1. Statistical records were accumulated for 556 sessions with 61 lessons.
2. On the average, 79% of the questions were answered correctly. A low score of 60% indicates that either the instructional material was inadequate or the questions were too difficult. A lesson at the high of 95% indicates that the questions should be more challenging.
3. The average time required to run a lesson ranged from 3.3 to 40.1 minutes, with an over-all average of 16.2 minutes.

```
                                                        Comments:
OLD AUTHOR                                              Go get the AUTHOR program
READY                                                   and run it.
RUN
ARE WE CHANGING AN OLD FILE? NO                         We are creating a new one:
FILENAME (NOT ALREADY IN USE!)? STUEXM                  Stutor example.
HOW MANY BLOCKS (APP. 350 CHAR. EACH)? 2
DO YOU WANT THE ANSWERS REVEALED? NO                    The answers will be in
                                                        the remedial frames.
F 1 ? WHO IS THE AUTHOR OF THE STUTOR SYSTEM?           Frame 1.
?                                                       Empty line.
  A 1 ? #DR.#JOHN#BURTON#                               The main answer.
C 1 ,S 1 ? R,2                                          Skip to frame 4.
  A 2 ? #BURTON#                                        Any answer with "BURTON."
C 2 ,S 2 ? R,1                                          Counted right, skip to 3.
  A 3 ? #                                               Any other answer.
C 3 ,S 3 ? W,0                                          Counted wrong. Do frame 2.
ONLY ONE MORE ANSWER!                                   Warning, by AUTHOR.
  A 4 ?                                                 Empty line, end of frame.
                                                        Frame 2: give a hint.
F 2 ? OK, 'NAME', I'LL GIVE YOU A HINT*-:  HE'S THE BALDEST ONE IN
? THE PHYSICS DEPARTMENT.  HIS NAME BEGINS WITH A 'B'.
? NOW, HO--WHO IS HE?                                   Note corrections.
?
  A 1 ? #DR.#HOH---JOHN#BURTON#                         Counted right, 2nd try.
C 1 ,S 1 ? 5,1                                          Skip to frame 4.
  A 2 ? #BURTON#                                        Counted right, 2nd try,
C 2 ,S 2 ? 5,0                                          give him full answer.
  A 3 ? #                                               Any other answer is wrong,
C 3 ,S 3 ? 9,0                                          and is the last chance.
ONLY ONE MORE ANSWER!
  A 4 ?
                                                        Frame 3: Give full
F 3 ? THE MAN'S FULL NAME IS DR. JOHN W. BURTON, 'NAME'!        answer.
?
  A 1 ? 'NONE'                                          No answer from student.
C 1 ,S 1 ? -1,0                                         No reinforcement, no
  A 2 ?                                                 credit.
                                                        Frame 4: arithmetic.
F 4 ? HERE'S AN ARITHMETIC PROBLEM, 'NAME':
?                                                       V(1)=even, 20-100.
? [20,100,2]+[21,99,2]= ?                               V(2)=odd, 21-99.
 ** V( 1 ) ** V( 2 )                                   Find the sum.
?
  A 1 ? [V(1)+V(2), .001]                               Correct answer, ±1%.
C1,S1,C2,S2? R,2,W,0                                    If correct, skip to end.
                                                        Frame 5: show the answer.
F 5 ? [V(1),0,0]+[V(2),0,0]=[V,0,0]                     V = previous correct
 ** V( 3 ) ** V( 4 ) ** V( 5 )                         answer.
?                                                       One blank on this line.
? SHALL WE TRY THIS LESSON AGAIN, 'NAME'?
?
  A 1 ? #Y#                                             Any "Y" = "YES."
C 1 ,S 1 ? -1,0                                         No credit, do next frame.
  A 2 ? #                                               All else = "NO."
C 2 ,S 2 ? -1,1                                         No credit, skip to end.
ONLY ONE MORE ANSWER!
  A 3 ?

F 6 ? BRNCH:STUEXM                                      Branch to start of this
                                                        lesson.
F 7 ? 'ED-ND'                                           End of lesson signal.
STUEXM IS FINISHED!                                     Message from AUTHOR.
```


Figure 4. Creation of a Tutoring Lesson by the AUTHOR Program.

```
OLD LISTOR                                                    Comments:
READY                                                         Go get the LISTOR program
RUN                                                           and run it.
FILENAME? STUEXM
OLD FILE: 2 BLOCKS, ANSWERS ARE NOT REVEALED.
WHICH FRAMES(INCLUSIVE)? 1,F                                  List frames 1 through the
 frame number                                                 final one.
  line number
 1.01 : WHO IS THE AUTHOR OF THE STUTOR SYSTEM?
 1.02 : <>                                                    Empty line symbol,< >,
 1.03 : #DR.#JOHN#BURTON#                                     printed by LISTOR,
 1.04 : R,2                                                   used by system to
 1.05 : #BURTON#                                              designate end of
 1.06 : R,1                                                   subsection.
 1.07 : #
 1.08 : W,0
 1.09 : <>                                                    Blank line printed by
                                                              LISTOR for clarity.
 2.01 : OK, 'NAME', I'LL GIVE YOU A HINT:  HE'S THE BALDEST ONE IN
 2.02 : THE PHYSICS DEPARTMENT.  HIS NAME BEGINS WITH A 'B'.
 2.03 : NOW, WHO IS HE?
 2.04 : <>
 2.05 : #DR.#JOHN#BURTON#
 2.06 : S,1
 2.07 : #BURTON#
 2.08 : S,0
 2.09 : #
 2.1  : 9,0
 2.11 : <>

 3.01 : THE MAN'S FULL NAME IS DR. JOHN W. BURTON, 'NAME'!
 3.02 : <>
 3.03 : 'NONE'
 3.04 : -1,0
 3.05 : <>

 4.01 : HERE'S AN ARITHMETIC PROBLEM, 'NAME':
 4.02 :
 4.03 :  [20,100,2] +[21,99,2]= ?
   ****  ** V( 1 ) ** V( 2 )
 4.04 : <>
 4.05 : [V(1)+V(2),ABS( .001+1E-5)]
 4.06 : R,2,W,0
 4.07 : <>

 5.01 :  [V(1),0,0] +[V(2),0,0] =[V,0,0]
   ****  ** V( 3 ) ** V( 4 ) ** V( 5 )
 5.02 :
 5.03 : SHALL WE TRY THIS LESSON AGAIN, 'NAME'?
 5.04 : <>
 5.05 : #Y#
 5.06 : -1,0
 5.07 : #
 5.08 : -1,1
 5.09 : <>

 6.01 : BRNCH:STUEXM                                          Two empty lines were
 6.02 : <>                                                    added by AUTHOR to end
 6.03 : <>                                                    the branch frame.

READY
```

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Figure 5. Sample Lesson Printed by the LISTOR Program.

TABLE II

STATISTICAL DATA ACCUMULATED BY THE COMPUTER FOR EACH LESSON

Value Measured	Gen. Phys.	Elem. Phys.	Rem. Math 1st Sem.	Rem. Math 2nd Sem.	All Courses	Low Value	High Value
No. of Lessons Recorded	48	2	8	11*	61**	-	-
No. of Students Enrolled	36	52	60	22	170	-	-
No. of Student Sessions	305	105	58	88	556	-	-
Avg. No. Students per Session	3.7	35	4.1	2.5	4.5	-	-
Avg. No. Sessions per Lesson	6.4	52.5	7.25	8.0	8.05	-	-
Avg. Learning per Session	4.0	4.0	3.4	4.2	3.97	3.0	4.9
Avg. Motivation per Session	3.6	3.8	3.8	4.0	3.72	3.0	4.5
Avg. Time (min.) per Session	14.6	16.3	7.0	15.9	16.2	3.3	40.1
Avg. Score per Session	79.0	76.1	68.2	89.3	79.0	59.8	95.0
Correlation of Learning w. Score	.183	.189	-.246	.006	-	-.644	.884
Correlation of Time w. Score	-.250	.008	-.077	.081	-	-.986	.613

* Includes 8 lessons in column 3. ** Excludes 8 lessons in column 3.

TABLE III

TABULATION OF QUESTIONNAIRE RESPONSES BY STUDENTS

Value Measured	General Physics	Elem. Physics	Rem. Math 1st Sem.	Rem. Math 2nd Sem.	All Courses
No. of Lessons Involved	48	2	10	14*	64**
No. of Students Enrolled	36	52	60	22	170
No. of Students Responding	29	52	51	17	149
No. of Students Using System	29	46	14	15	104
No. of Sessions Reported	873	140	70	190	1273
Avg. No. Sessions per User	30.1	3.0	5.0	12.7	12.2
No. of Sessions Completed	447	121	65	165	798
Avg. No. Sessions Completed	15.0	2.3	4.6	11.0	7.7
No. Students with Difficulty	1	4	1	0	6
No. Students with no Difficulty	28	42	13	13	96
No. of Users with no Response	0	0	0	2	2
Time spent, min. per week	41.3	-	26.9	28.8	34.6
Avg. Learning Value (1--5)	4.2	-	3.2	3.7	3.8

* Includes 10 lessons in column 3. ** Excludes 10 lessons in column 3.

4. The linear regression for time versus score yields correlation coefficients ranging from -0.986 to +0.613. The large negative value indicates that students experiencing difficulty are spending more time with those lessons, while lessons with a positive value may be slighted by the poorer students.

5. The student's estimation of the educational value of the lessons ranged from 3.0 to 4.9 on a 5 point scale. A few mediocre lessons need improvement.

6. The correlation coefficient for learning value versus score tends toward zero, indicating that the evaluations were not affected much by the score.

7. For each lesson, students rated the degree of motivation toward learning. These assessments ranged from 3.0 to 4.5 on a 5 point scale. The lessons with lower ratings should be reworked to make them more interesting.

To supplement the data provided by the computer programs, questionnaires were given to the students at the end of each course. The results are tabulated in Table III. In contrast to the data in Table II, this information reflects the students' retrospective assessments regarding the lessons used for an entire course.

From the data in Table III the following conclusions may be drawn:

1. 170 students were enrolled in four classes, utilizing 64 tutoring lessons (three of these were not included in Table II).

2. Of the above students, 104, or 70% of the 149 responding to the questionnaire, made some use of the tutoring system.

3. On the average each student started 12.2 sessions and completed 7.7 sessions during each semester. Apparently many lessons were terminated prematurely either by student choice or by error.

4. Only 6% of the students using the system reported any difficulty in learning how to operate the tutoring lessons.

5. Among the four classes the average amount of time spent per student ranged from 26.9 to 41.3 minutes per week.

6. Total use of the tutoring system averaged about 60 hours per week or 12 hours per terminal each week. This represents less than 20% of the total use of the computer facility for all purposes (this system is only used for teaching and research).

7. The verbal evaluations of the learning value of the lessons, converted to a scale of 1 to 5, ranged from 3.2 to 4.2, or average to good. This compares rather well with the corresponding values in Table II.

Three instructors and two students made use of the AUTHOR and EDITOR programs in creating lessons for the STUTOR system. An instruction manual and 4-6 hours of training served to introduce them to the techniques required to produce lessons. They were asked to respond to a questionnaire which evaluates the STUTOR system. The five authors prepared approximately 23 lessons each, spending an average of 1.4 hours preparing and testing each lesson. Typically, the instructors would spend from 1 to 3 hours on a lesson, while the student assistant would spend from 0 to 2 hours in completing a lesson. The total estimated student time for all lessons produced is 15.8 hours. Authoring time was estimated to be 124 hours, thus requiring about 8 hours of authoring time to produce an hour of tutoring.

The five authors rated the system in terms of ease in mastering its operation, on a scale of 1 to 5. The ratings ranged from 2, or moderately difficult, to 5, or very easy. All five of them rated the system very easy to use, once the principles of operation were mastered. The three instructors rated the system high in terms of its potential usefulness. The lessons produced were judged to be valuable for future use both to these instructors and to others teaching similar courses.

CONCLUSIONS REGARDING THE STUTOR SYSTEM

The STUTOR tutoring system appears to be a useable educational tool, primarily as an adjunct to basic course materials. Limitations of throughput in such a small system tend to mitigate against its use as the primary means for teaching a course. However the structure of the system allows flexible application to both verbal and numerical tutoring. The verbal processing is sometimes slow, but the numerical power afforded by the BASIC interpreter is both fast and effective. The syntax is simple enough that the non-programmer can use the system without extensive training. The automatic handling of the student's name and bookkeeping of his performance relieves the instructor of unnecessary chores.

The student's evaluations of the tutoring system indicate that the lessons provide an effective and interesting teaching tool. The instructors also judged that the material was highly motivating and that the students profited from the lessons. As with any other teaching medium, the successful application of this CAI method depends heavily on the creativity of the authors and the manner in which students are encouraged to use it. Continued use of STUTOR should result in additional production of interesting material.

Operating a tutoring system with constraints of memory space and execution speed are clearly limitations in this system. The data files are all open to the public, which prevents secure and error-free collection of student performance data. Memory limitations also prevent automatic recording of statistical data. More memory would permit storage of a larger number of instructor's answers and/or random variables.

The STUTOR system may be implemented immediately at many installations already

in operation. Any EDU25 system can accept the modification patch. The BASIC programs and data files of the STUTOR system can operate under either the original or the modified EDU25 interpreter. With modification STUTOR may also operate under many similar interpreters. The programs and data files can be distributed by paper tape or by magnetic tape. Listings and paper tapes of the STUTOR system programs and data files, the tutoring lesson files, and the modification patch to EDU25 may be obtained at cost from the first author at Box 1917, Carson-Newman College, Jefferson City, Tennessee 37760.

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Computer Simulation and Role-Playing as Methods for Teaching Interviewing

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Abstract

The essence of nursing practice is the nursing process, a method of problem-solving. As in any problem-solving process, management of a client's problems depends upon the data gathered. Nurses gather data by interviewing and physically examining clients. The interview is often the first contact between a client and the health care delivery system. Most nursing students are beginning interviewers. Studies have identified behaviors which are typical of beginning interviewers. Current methods of instruction for the practical application of the theoretical content related to interviewing have proved inadequate. During Fall, 1978 forty-five junior nursing students in an upper division, integrated baccalaureate program located in the Midwest were studied in relation to the differences between using role-playing and computer simulation for practicing the techniques of interviewing. Two of the students were male; all students were between the ages of twenty and thirty-five. A Post-Test Only design with experimental and control groups was utilized. Subjects recorded real client conversations in the community. Using a one-hundred item checklist, average scores of four judges were compared. No significant differences were found at the .05 level in either the amount of data collected or the number of errors made in use of interviewing techniques. On individual items, the experimental group was favored for role definition and length of time for completion of the interview; the control group was favored for collection of data related to a person's status in life. The analysis of highest and lowest scorers revealed that increased age and previous experience with computers may contribute to one's ability to interview; previous experience with interviewing may interfere with one's ability as measured in this study. Students generally expressed positive comments about using the computer as an instructional tool. For this group of students, computer simulation appears to be as effective as role-playing, a more traditional approach in terms of correct use of interviewing techniques and amount of data collected.

Method

Objectives. The following objectives were identified for the development of a computer simulation program for the practical application of the theory of interviewing techniques: 1) identification of an individual student's ability to utilize interviewing techniques; 2) verification of the completeness of the student's data base; 3) focus on content and use of the techniques to gather data rather than on the significance or meaning of the client's behavior; and 4) the verification of the ability of the computer simulation program to be an effective instructional method in providing practice in interviewing clients.

Judgment Model. A one-hundred item checklist was developed to facilitate evaluation of subjects' tape recorded interviews with their clients. This instrument consisted of items identified in a review of the literature and those from an instrument tested at the University of California (Brody, 1973). Subjects' use of interviewing techniques and amount of data collected were the major areas evaluated.

Computer Simulation Experience. A detailed description of a hypothetical

client who was five months pregnant was written as a computer program in the BASIC language. The student interviewer was guided through a series of twelve programs: introduction, reason for the visit, biographical data, health status, neighborhood, marital status, financial status, home, persons living in household, persons living outside the household, valued person in life, and end. These programs were chained together by a Select program. The student must gather complete data in a logical sequence. An instructor was built into the program to prompt the student and give feedback on the student's questions and responses. It took the average student one hour to complete.

The computer experience was originally developed to run on the college's main computer, a Sigma 6. It has been recently modified to run on a Radio-Shack Level II with one disk drive microcomputer.

Role-Playing Experience. Each pair of students role-played gathering data from each other by interviewing in a laboratory setting with one instructor present.

Design of the Study

Early in the term and prior to receiving any theoretical content on interviewing, fifty generic, not Registered Nurse, junior students enrolled in Nursing I fall term, 1978, were asked to participate in the research study.

Forty-five of the fifty students volunteered to participate. One Registered Nurse student, the only other member of the class, had previously been excluded from participation in the study. The investigator decided her previous education in nursing would unduly influence her score.

Following signing of consent forms, the students chose code numbers from a prepared list from 1 to 50. From that time on, all subjects were identified only by those numbers to protect their anonymity. Subjects were randomly assigned to Control or Experimental groups by drawing either the word Control or Experimental from a bag as they reentered the classroom following the break.

All students enrolled in Nursing I fall term, 1978, attended a fifty minute lecture presentation on interviewing during the second week of the term. Students had required readings on interviewing in preparation for the class. Short, videotaped interview sessions produced by previous nursing students with drama students acting as clients were critiqued during this class presentation.

The Control group and six students not participating in the study practiced gathering data from a Client Assessment Guide with each other in pairs in a laboratory setting during the third week. Each student experienced being the interviewer and interviewee. Following this one-two hour session, these students obtained their client's consent and tape recorded their interview with them.

The Experimental group individually practiced gathering data from a Client Assessment Guide with the computer portraying the client. Following this one-two hour session, these students obtained their client's consent and tape recorded their interview with them.

The tapes were turned in to the investigator as they were obtained over a four-five week period. The investigator distributed them to the judges.

Data collection. After the tapes were distributed, four judges listened to each tape recording independently and in any order she desired. The average score of the four judges was utilized for comparison between groups.

Fifteen tape recordings were not able to be included in the study. Reasons given to the investigator by the subjects were: 1)client refused - one student; 2)client turned out to be a friend - one student; 3)forgot to turn on the tape recorder - one student; 4)did not push the record button hard enough - one student; 5)tape jammed - two students; 6)recorder did not work - two students; 7)no tape recorder available - one student; 8)did not plug it in as thought it was battery operated - one student; and 9)unable to hear conversation of five students and clients.

One third of the subjects were thus eliminated from the study. The investigator recognizes the possibility of this missing data's effect on the study. Therefore, the investigator statistically analyzed all four groups: experimental group in the study (N=12); experimental group eliminated from the study (N=11); control group in the study (N=18); and control group eliminated from the study (N=4); according to the representativeness of the subjects on the characteristics depicted on the Student Data Form. The investigator was also concerned about the loss of forty-eight percent of the experimental subjects as opposed to the loss of eighteen percent of the control subjects.

Subjects in the experimental group were also asked to comment anonymously on the computer simulation immediately upon completion of the program. They were also formally interviewed by the

investigator after all subjects had completed their first home visit.

Results

Hypothesis I. Baccalaureate nursing students who are given an opportunity to practice interviewing a client by computer simulation will gather data as complete as similar students who role-play this experience.

The investigator analyzed the amount of data scores by the parametric statistical techniques of the t-test and one-way ANOVA. There was no difference in the amount of data collected between groups at the .05 level of significance. See Table 1.

Table 1. Analysis of Amount of Data

Source	Experimental	Control
Number	12	18
Mean	37.104	37.875
t Test	-.3638	
Alpha at .05	2.048	
Eta squared	.004	
F ratio	.1322	
Alpha at .05	3.34	
Eta squared	.0046	

Hypothesis II. Baccalaureate nursing students who are given an opportunity to practice interviewing a client by computer simulation will make as many errors in technique as similar students who role-play this experience. There was no difference in scores between groups at the .05 level of significance. See Table 2.

Both hypotheses were accepted as there were no significant differences at the .05 level that were detected by this study. The strength of association measures that were also calculated showed very little of the differences were accounted for by the computer simulation experience.

Analysis of highest and lowest scorers. The investigator also analyzed the characteristics of the five subjects who obtained the highest scores. Compared to the total subject population profile, these subjects were slightly older, were all female, had slightly lower grade point averages, were more lacking in interviewing experience, and had had more experience with computers. See Table 3.

Table 2. Analysis of Use of Interviewing Technques

Source	Experimental	Control
Number	12	18
Mean	31.145	30.291
t Test	.6609	
Alpha at .05	2.048	
Eta squared	.02305	
F ratio	.4365	
Alpha at .05	3.34	
Eta squared	.0153	

Analysis of the characteristics of the five lowest scoring subjects revealed that they were slightly younger, were all females, had slightly lowere grade point averages, had more interviewing experience, and slightly more experience with the computer than the average subject. See Table 3.

It would appear that older students who have had previous experience interacting with computers but who have had little previous experience interviewing were able to obtain higher scores. The younger subjects who had had less experience with computers but had had more experience interviewing obtained the lowest scores. As measured in this study, increased age and previous experience with computers appears to be facilitative. Previous interviewing experience appears to be detrimental.

Analysis of Students' Comments. In order to evaluate the computer simulation experience more completely as an instructional tool, students in the experimental group were asked to comment anonymously in written form immediately following the

computer interview. They were not given any instructions on what comments to make. Twenty-two of the twenty-three students complied. Only one student made totally negative comments. Positive comments were: 1) perceived experience as interesting, helpful, enjoyable, and applicable to a real client situation; 2) increased their confidence and feelings of preparedness; 3) desire to spend more time with the experience; 4) decreased feelings of anxiety in attempts at formulating questions and making mistakes; 5) assisting to organize and prioritize for more complete data collection; 6) instruction in how to ask questions, the importance of word choice, how to continue conversation, and use of different approaches; 7) identification of importance of noting clues in client's data and remaining on the topic; 8) reliance on own ability to carry the conversation and the client's responses stimulating thoughts in the students; 9) immediate individualized feedback on mistakes with alternative approaches provided; 10) realism of simulation; and 11) allowing students to be themselves. Negative comments were: 1) lack of ability of computer to respond appropriately to their input; 2) simulation was lacking in realism; 3) produced feelings of frustration; and 4) did not allow students to be individuals.

Table 3. Subjects' Profiles

		Mean	SD	Sx
Total Scorers	Age	1.711	.7574	.1129
	Sex	1.044	.2084	.3106
	Grade Point Average	3.298	.2628	.3918
	Interviewing Experience	.466	.5045	.7521
	Computer Experience	.355	.484	.7216
Highest Scorers	Age	1.8	1.166	.583
	Sex	1		
	Grade Point Average	3.026	.1745	.0872
	Interviewing Experience	.2	.04	.02
	Computer Experience	.8	.04	.02
Lowest Scorers	Age	1.4	.489	.2445
	Sex	1		
	Grade Point Average	3.116	.1213	.06
	Interviewing Experience	.6	.04	.02
	Computer Experience	.4	.04	.02

Sex: 1=female; 2=male
Interviewing Experience: 1=experience; 0=no experience
Computer Experience: 1=experience; 0=no experience

After these students completed their initial home visit to their client, the investigator interviewed each student in a formal manner. Technical difficulties with the main computer and related malfunctions which resulted in a lack of appropriate response to student input were still mentioned as problem areas. Some students also desired more familiarity with a computer and the individual program to be run. Other comments of the students were similar to those given immediately following the computer experience.

Results of Other Studies. The results from this study are similar to others discovered in a review of the literature wherein their was no sognificant difference in performance between experimental and control group where computer simulation was compared with traditional methods of instruction.

Discussion

The results indicate that computer simulation was as effective in teaching interviewing techniques as role-playing, a more traditional method. These results are limited by the small sample size and disproportionate loss of data from the experimental group. In addition, a setting that was convenient was chosen by the investigator.

Students perceived that the computer simulation experience was valuable as a learning experience. Negative comments centered around inappropriateness of computer response to their input on occasion. This was due both to technical difficulties in operating the college's main computer and programming "mistakes". This is a major problem in using the free-response mode. BASIC is not a language which facilitates the interactive, dialogue mode. The investigator suggests

use of PILOT which is more facilitative.

Students voiced a need for more complete orientation to the use of a computer and the program to be run. The orientation session had consisted of a brief demonstration with further direction given within the program itself.

This year the same program was modified for use on the Radio-Shack Level II microcomputer with one disk drive. Students were oriented in a thirty minute slide lecture/discussion presentation. Content included hardware of the computer and the introduction section of the program. Further direction was given in the program. There was an actual demonstration on the computer itself immediately following the lecture/discussion. There was an obvious decrease in the number of requests made for assistance. A photographic guide was also developed to help ensure proper sequencing in loading the program when students returned for their individual session. Only one student asked for assistance in loading the program after the guide was developed. In this investigator's opinion, fostering of independence and self-confidence are important considerations to be considered in introducing innovative teaching methods.

Future

Research studies which verify existing data or contribute new perspectives to the use of the computer as an instructional tool are crucial to the intelligent use of computers in education in the future. Many innovative programs are being developed across the country in all educational fields. Little evaluative research has been published in the past. The studies that were reviewed by this investigator did not suggest conclusive findings.

New methods for detecting differences between using one method over another need to be developed. All aspects of educating students need to be evaluated in relation to using computers as instructional tools. Retention and measuring learning at various time intervals has not been an area of interest in the past. Additional research is necessary to fit teaching techniques to the individual learning styles of students. The majority of students appear to be highly motivated by the use of the computer for learning purposes. They find working with a computer to be helpful and enjoyable. Educators must capture and hold this interest for the future.

References

Brody, H.A., Lucaccini, L.F., Kamp, M., & Rozen, R. Computer based simulated patient. Journal of Dental Education, 1973, 37, 27-31.

MICROPROCESSOR-BASED CAI TECHNIQUES IN DIAGNOSTIC RADIOLOGY FOR SENIOR MEDICAL STUDENTS

James M. Swain

La. State University Medical Center

ABSTRACT

Interactive CAI techniques using side-by-side self-contained 35 mm projector and CRT terminal, microprocessor-based, are described in a program for presenting imaging materials to senior medical students in diagnostic radiology. By keyboard, light-pen, or voice, the user response is incorporated into a systematic learning experience based upon actual images. Computer-produced sketches supplement the analog images for underscoring pertinent concepts of pattern-recognition and problem-solving.

The application of CAI in diagnostic radiology for senior medical students may at first glance, seem inappropriate. Evaluation of imaging data, learning pattern-recognition, and correlation with clinical problems leans heavily upon the image itself (roentgenogram, CT scan, nuclear medicine study, ultrasonographic representation, etc.). Only a limited didactic interactive instruction can be useful without the visual presentation.

In the Department of Radiology, Louisiana State University (New Orleans) a program of interactive CAI supplementary instruction is being offered within the past year using a small microprocessor-based unit (1) and a self-contained projector using 35 mm slides (2). The two are interconnected by means of a relay thru the "game paddle" outlet. This allows projected 35 mm slides of selected radiological cases to be an integral part of the program.

The problem of directing attention to important parts of the projected image seemed to call for specially-prepared slides using arrows, lines, letters, and all of the other graphic devices so familiar to readers of radiologic literature. However, by means of an input graphic tablet ("bit pad"), line drawings of pertinent images have been projected to the CRT from computer-based graphics allowing side-by-side comparison for the user. The usual question/answer format can be applied to images as well as textual presentation.

As an additional method of stimulating user interest, a "light-pen" (3) is used. The position of this pen can be detected by the computer-program which allows the user to indicate a response to the computer-based image. This permits questions to be asked concerning the adjacent projected image with a minimum of accompanying text. Still experimental and thus very tentative, the use of voice-actuated circuitry is being tested as a third means of user-input.

The techniques here described are too new in our hands for critical evaluation and this is more in the nature of a work in progress. However, the ready availability of this hardware at a cost within the reach of most academic departments (or even individual instructors), makes this form of CAI particularly attractive.

(1) Apple II, Apple Computer Co.
(2) Kodak Ektagraphic 450 Audio Viewer, Eastman Kodak Co.
(3) Lipson Light Pen, Columbia, Maryland

USING CMI IN TEACHING

INTRODUCTORY COLLEGE COURSES

Dr. Henry D. Olsen

Medgar Evers College

INTRODUCTION

Mass lecture instruction in higher education, especially at the introductory level, is a fact of life on many campuses. Instructional resources, unable to keep pace with growing enrollments have forced many departments to expand their introductory-level classes into mass lecture courses serving hundreds of students. However, whatever educational benefits are derived in the name of efficiency are often counterbalanced as students and faculty are forced to interact with one another in the decidedly impersonal classroom context necessitated by mass lecture instruction.

Indeed, difficulties associated with mass instruction in higher education has been noted by a number of authors (Baker and Behrens, 1971; Wallis, 1973; Wallace, 1974; Moxley, 1974). At the heart of the problem seems to be the fact that large classes are almost invariable composed of students with heterogeneous interests and abilities, and instructors are typically hard pressed to accommodate such diversity. Forced to tailor the content of instruction to some dimly perceived "typical" or "average" student, the instructor may be proceeding too fast or too slow for most of the class. More importantly, even if the pace of instruction is satisfactory for the majority, it is more than likely that many students will be experiencing difficulty while others will remain unchallenged.

Two solutions to this dilemma of mass instruction have gained some popularity. The first involves the use of small discussion groups as either a supplement or substitute for the mass lecture format (Baker and Behrens, 1971; Wallis, 1973; Wallace, 1974). Whether run by faculty or graduate or undergraduate teaching assistants, discussion groups can be used not only to individualize instruction but also to overcome the alienation and passivity associated with mass lecture attendance. A second solution is Keller's Personalized System of Instruction (PSI) which employs a self-paced, mastery-learning approach (Clark, 1974; MacDaniel, 1974; Malec, 1975). PSI is unique in that individualization is achieved by allowing students to progress through the course at their own speed while simultaneously providing each student with frequent face-to-face instructional assistance.

EDUCATIONAL PREMISES OF CMI

CMI is designed to help the instructor measure and evaluate student performance throughout a course and to plan effective teaching strategies every step of the way. The system is applicable in courses of any size and any academic discipline but it is most easily adopted in courses with well-established goals and objectives.

CMI is in no way meant to be a substitute for classroom instruction, but rather a supplement to it. It should be seen as a clerical and organizational aid to the instructor and as a valuable feedback mechanism for students. As such, it can only be as successful as the course for which it is being used.

Any CMI system is only one means to evaluate studens, but certainly not intented to be the only means. It is specifically not mean to replace such important evaluation practices as essays and written papers, for these can test students in ways that multiple-choice tests can't--individual approach to a

problem, choice of details, writing style, execution of an argument, and so forth. Without these kinds of tests, students have no opportunity to actively express themselves in their own words. Rather than thinking of multiple-choice tests and written tests as mutually exclusive, the instructor can use each type to complement the other. Careful application of multiple choice questions, which tend to promote precision and logical clarity, should only strengthen a student's ability to give his knowledge written expression.

CMI is now being used in a variety of teaching situations with great success. Instructors find CMI indispensable since it now performs a great deal of the staff's work in a fraction of the time that used to be spent. Educationally it is found to be extremely beneficial; instructors find it useful in evaluating students, and students find it helps motivate and guide their work.

ADVANTAGES OF CMI

There are many facets of CMI which make this educational technique advantageous to both instructional and learning populations. For the instructor CMI can:

perform most clerical tasks, including scoring of tests and computer generation of test;

provides useful data in the form of (1) a report to each student and (2) reports to the instructor and instructional staff charting each student's progress and giving a statistical analysis on responses to test questions;

provide an open-ended structure for an instructor to organize in detail the objectives of a course;

can be used effectively with a self-pacing strategy. For example, an instructor can provide a syllabus outlining course material and test units which accompany that material;

is user-oriented, or "interactive," and written in English and not Computerese; all instructor interaction with the computer is by means of easily-understood question-and-answer sequences at a terminal;

provides a neat, useful repository for an instructor's notes and course ideas in question or exercise format.

FOR THE LEARNER CMI CAN:

provide students with a means to test themselves on course materials and to see where they stand;

gives students a chance to take tests over again as many times as an instructor specifies. Most students find this welcome alternative to the one-shot final exam. Studies show that students also learn and retain more by gradual study than by "cramming;"

provide students with a test report within minutes of taking a test;

provide, as part of the student test report, an 'individual' prescriptive assignment (derived from the student's reresponses) outlining his areas of weakness, and, at the discretion of the instructor, listing questions, reference material, and other study suggestions;

provides a means for students to set their own goals and to pace themselves.

SYSTEM SEQUENCE OF CMI

CMI has been designed to perform 4 general functions (1) register a course and students, (2) produce tests, (3) administer and score tests, and (4) report to instructors on student performance and on test responses.

Listed below is an outline of the system sequence.

1. Course and Student Registration

CMI requires that the user supply general course information (school and department name, course number, section, instructors, teaching assistants) as well as the names and ID numbers of enrolled students. CMI allows for easy changes or additions to entered information. The first step in CMI is to provide general information describing the course. The second step is to register enrolled students by entering their names and ID numbers under sections defined by the particular instructors and staff.

2. Tests

Once a course has been registered, test questions can be entered. Format, content and length are entirley up to the instructor; the only restriction is that questions be in multiple-choice form.

3. *Testing and Scoring*

During the semester, when a student is ready to test himself on course material, he reports to the testing site or center. The student receives a printed copy of the test and a special OMR (Optical Mark Read) gridded card on which to record answers.

The student reads each test question in turn and pencils in the box on the OMR card which corresponds to the correct answer. When the pencilled-in card is fed into the card reader at the testing center, the system validates the identifying data and logs the student into the system. In a matter of seconds, the student receives a printed report of how he did on the test, showing his score and the objectives and questions missed, and giving prescriptions for those missed.

It is possible to print student reports on multiple copy paper so that the student, testing site, and instructor may each have copies.

A record of student scores and question choices is stored by the computer for subsequent student analysis and item analysis by the instructor.

4. *Reporting to the Instructor*

CMI can produce various kinds of reports, depending on the kind of analysis and the extent of information needed. In response to demands by instructors, CMI produces two basic types of instructor reports--the Student Performance Report, which provides comparative information on the performances of students in the course, and the Item Analysis, which provides a statistical breakdown of responses to test questions.

STUDENT PERFORMANCE REPORT

The Student Performance Report can be produced according to a variety of parameters, or specifications set by the instructor. Reports can be produced to include, for example, data on: 1. all students in a course, 2. all students in a particular section, 3. all students having a particular tutor.

The instructor has a record of student performance from a qualitative as well as strictly quantitative standpoing. For example, the instructor can see that Daryl Zanuck improved his score on the retest but that he missed different objectives the second time around. He can also see that one student who had exceptionally good scores steadily improve even more, while another student failed all the objectives and only took the test once. The instructor thus has a comparative reading of that particular tutor's section as well as a handle for probing into particular student problems.

THE ITEM ANALYSIS REPORT

The second type of report, the ITEM ANALYSIS, gives statistics on student responses to test questions.

The advantages to the instructor of such statistics have been discussed earlier; basically they are helpful in alerting him to general class problems and individual pitfalls. They are also beneficial in evaluating the effectiveness of the tests and the teaching methods used.

PRE-COURSE PLANNING FOR CMI

Below is an outline of some principal suggestions to follow in adapting your course for CMI. You will find in this outline general guidelines for building a test, applicable to any course of instruction, including specific hints for writing test questions.

1. *Defining Objectives*

   Start by clearly setting forth objectives, or general conceptual areas to be covered during the course. These can be gleaned from any course plan.

2. *Building Test Questions*

   Once objectives are drawn up, writing test questions become much simpler. The instructor's task is how to prepare test questions that best assess and measure the objectives set forth.

3. *Structuring a Balanced Test*

   Good tests should reflect the course material. They should include a representative sampling of subject content. However, a teacher may want to test certain objective more rigorously than others. An objective can be given more weight by having more questions in it, or by being assigned more questions in each version.

4. *Question Construction*

It is possible to use ingenuity in writing test questions. Constructing imaginative questions that guage understanding of fine points of course material as well as testing minimum knowledge is important and useful in classes that are either large or composed of varying student levels.

5. *Writing Prescriptions*

Prescriptions can take the form of comments, directions, assignments further study, or anything the instructor choolses. Listed below is a chart of the three possible situations for prescriptions within the framework of CMI.

6. *Designing to Specifications*

The instructor must know in advance how many questions he wants to appear in each computer-generated version. In order to randomly generated test versions that are sufficently different, the system must be supplied with a surplus of questions.

7. *Testing the Test*

"Testing" the finished test itself is probably a good idea for teachers no matter how experienced in this kind of testing. In this way they can be assured that the questions and areas tested are well-balanced. It might even be helpful to give the test to an assistant or someone else just to get a reaction, and to get out any remaining "bug" in the test-examples of poor or unclear wording, self-defining answers, or possible discrepancies between the questions and their respective answers.

CONCLUSION

Many CMI instructional system utilize a computer terminal with a television-like screen which has the capability of two-way communication between the instructor and the computer. The instructor simply sits at the terminal, and answers the system's requests for information using the terminal keyboard. The importance of the system design is that the instructor does not need to know any computer language to be able to work with CMI, and that a computer expert is not required to operate the computer. Since students do not use the terminal, no special student training is necessary either.

A COMPUTER MANAGED INSTRUCTIONAL PROGRAM

FOR TEACHERS OF LEARNING DISABLED STUDENTS

Dr. Melvin Samuels AIU

Ms. Barbara Minick AIU

ABSTRACT

The Allegheny Intermediate Unit has developed a computer based resource information system for learning disability teachers. The system provides teachers with lists of teaching techniques and instructional materials that are appropriate for individual student's needs. In addition to the descriptive listing, the printouts also identify the location of the material and designate other students in the same class for which the material would be appropriate. Teachers feed basic assessment information and updated records on each student into the data bank, and the computer matches this information with lists of materials and techniques that were programed prior to the school year. Based on initial assessment information, the computer is able to generate a portion of a student's Individual Education Plan (IEP). An additional feature of the system is its capability to produce individual progress reports four to six times a year. These reports are matched directly to the IEP. Parents, administrators, and project staff provide continuous input through an advisory council structure.

Prescribing individual instruction for special education students has become a very time-consuming concern of educators. The Improved Individual Instruction Program (I.I.I.P.) is an outgrowth of this concern and was developed as a means of providing a more efficient and accountable system of individualized instruction. The I.I.I. Program is a federally-funded project under Title IV-G which services learning-disabled (L.D.) students within the Allegheny Intermediate Unit, Exceptional Children's Program, Pittsburgh, Pennsylvania. The Exceptional Children's Program services 13,000 children, grades K-12, in the 46 suburban school districts in Allegheny County. Approximately 2,400 of these children are diagnosed as learning disabled.

The I.I.I. Program is a computer managed instruction program (CMI), maintained on a Hewlett-Packard 3000, Series II computer, which provides teachers with lists of teaching techniques and instructional materials that are appropriate for individual students' needs based on performance data maintained in the computer.

An outgrowth of the initial assessment information provided by the teacher for each child is a computer-generated portion of an IEP. Paralleling the IEP is a progress report which is generated for use during parent/teacher conferences.

RATIONALE FOR THE PROJECT

In the 60's, the Association for Children with Learning Disabilities (ACLD) first identified the problems of L.D. students. Allegheny County responded to this need by opening two of the first learning disabilities classrooms in the country. Since this time the program has mushroomed each year until it has reached its present number of 150 classrooms. The demand from parents and administrators to open many more L.D. classrooms has been a constant one. The L.D. program has received a lot of support and positive publicity resulting in a "label" which is not stigmatizing to parents or students.

In the early 70's, service was expanded to include secondary classes. Comprehensive perceptual, reading, math and language skills checklists were developed to offer intensive individualization and

remediation. The curriculum has used a task-analysis skill approach with strong emphasis on academics. Assessments were developed to correspond to each skill on the checklists. From the diagnostic information on the skills checklists, a prescription (forerunner of the Individualized Education Program - I.E.P.) was developed. Teachers would then match appropriate teaching materials and techniques to the prescribed skills.

Since the major thrust of the program is on an individual skill analysis, the amount of paper work and recordkeeping is very time-consuming. As pupil population doubled and tripled, economics forced teacher numbers to remain constant. This caused the burden of paperwork and recordkeeping as well as "teaching load" to become overwhelming for teachers. The concept of a computerized resource retrieval system and tracking program was considered in an effort to lessen the paperwork, yet increase teacher efficiency and accountability.

COMPUTER MODEL DEVELOPMENT

Other computer retrieval systems were studied for their effectiveness. CMI models were operating in Ohio, South Dakota, Kentucky and Florida. Two systems specifically studied - Skiltrac, Center for Educational Innovation, Columbus, Ohio and the Child Based Information System, Central Susquehanna Intermediate Unit, Lewisburg, Pennsylvania, offered resource information and reporting systems but did not cover the range or level of academic skills needed for elementary and secondary grades.

Objectives and needs for a system designed specifically for an academic curriculum in grades K-12 were established by L.D. staff. Mr. Russell Guthrie, former Computer Services Director for the Central Susquehanna Intermediate Unit assisted in the Systems Analysis design for the model.

From the systems already in use, the following strengths were incorporated:

1. The use of efficiency grouping data.
2. The use of a "reminder" loop if skills have not been mastered.
3. The review and use of already developed teacher in-service training models.
4. The use of the logic and design of other computer program.

Of the weaknesses identified in other systems, the I.I.I. Program attempted to remedy two major ones:

1. Data entry problems.
2. Turnaround time for teacher receipt of information.

Features which are incorporated in the I.I.I. Program are:

1. The program allows for a wide range of teacher choice and involvement in the design and programming process.
2. The program provides the location of materials suggested for use.
3. The program provides evaluation data on materials and techniques used by teachers.
4. The program allows for teacher selection and incorporation of techniques and analysis of materials.
5. The program has been field-tested for two years.
6. The program provides for efficient ordering of instructional materials by tracking most-used and most-effective resources.
7. The program provides a student-tracking component which can generate a portion of a student's IEP as well as periodic performance updates.

Attachment A is a graphic overview of the I.I.I. Program.

OBJECTIVES OF THE PROJECT

The purpose of the Improved Individual Instruction Program is to design an individually prescribed system which will aid classroom L.D. teachers in developing and updating IEP prescriptions and techniques, maintain complete student records and evaluate the effectiveness of the materials and techniques used.

The project has three primary goals:

1. The systems will result in increased teacher efficiency and proficiency.
2. The program will enable supervisors to work more closely with teachers by providing a better understanding of what has occurred in those classrooms.
3. The program will result in greater parent information and satisfaction.

FUNDING AND OVERVIEW OF SYSTEM

The original proposal was submitted to the Bureau of Education for the Handicapped in December of 1976. Funds were received under Title VI-G to begin program operations in July, 1977.

The operations of the computer system begin immediately after initial assessment is done on the student in the L.D. classrooms.

Academic strengths and weaknesses are coded for each student and teachers prioritize those weak skills which will receive instruction during each grading period. The resource information bank then generates a list of suggested resource materials and strategies that are appropriate for individual student's needs. All suggested materials are readily available to the teacher in his/her classroom or through the Western Pennsylvania Special Education Regional Resource Center. In addition to these sources, teachers may also borrow selected materials from the I.I.I. Program Resource Center which has been specifically designed as a lending service. The I.I.I. Program is based on the conviction that teacher judgment is the most valuable aspect of the program. From the suggested list of resources, teachers choose those materials which would be most effective with individual students. This belief assures that the computer does not become the "prescription writer" and will allow teachers to address both the individual student's learning style and the individual teacher's teaching style.

In addition to the descriptive listing of resource materials and their locations, information is provided indicating the publisher, page number, level and whether the resource is a priority or supplementary item. Priority is defined as material that is available in most L. D. classrooms. Supplementary is used to designate new items or materials not readily accessible to teachers. This category is helpful for the experienced teacher who has used most of the items in his/her room and is looking for new material. It is also useful to the beginning teacher who is not yet familiar with the content of all the material in the classroom. An additional feature of the teaching program allows the computer system to identify other students in the class working at the same skill level for grouping purposes. Attachment B is a sample printout of suggested resource materials and student groupings.

Another aspect of the computer system involves recordkeeping and accountability. A portion of an IEP can be generated from the initial assessment information given by the teacher. This portion does not represent a complete IEP but merely identifies certain basic demographic data and skill areas needing remediation during the current year. Teachers must still identify additional academic and perceptual areas and must determine success criteria in every instance. Refer to Attachment C for a sample computer-generated portion of an IEP. Note that it contains an annual goal and short term objectives as well as evaluation procedures.

The system has the capability of producing individual student performance reports four to six times a year. Teachers administer mastery tests for skills remediated. This information is stored in the data bank and student reports are periodically updated throughout the year. Refer to Attachment D for a sample Performance Report Form. Note that the report form parallels the objectives on the IEP and contains a more detailed listing of skills matched to periodic performance updates.

EVALUATION TO DATE

Following the field-testing phase involving four teachers in L.D. classrooms during the first year, the computerized resource system was extended during the second year to 12 L.D. classrooms.

The listing of suggested resources, grouping of students with similar skill weaknesses and mastery tests are features which were suggested by the teachers during pilot phases. The biggest bonus however, seems to be the ease and time saved in doing IEP's and in recordkeeping.

Attachments E and F indicate teacher and parent reaction to the computer-generated portions of the IEP.

Other evaluation instruments which have been developed and are being utilized include an assessment of on-going project operations as seen by teachers and supervisors; evaluation of resources in the data bank for effectiveness, appropriateness and future ordering purposes; teacher knowledge of resource materials; quantity and quality of skill information on the IEP; teacher/parent/supervisor information reports; and math/reading achievement score information for students in project classes.

It is still too early to have definite results on any of these areas but findings do seem to indicate:

1. IEP development time is markedly reduced when using the computer program.
2. Teachers are conscientiously evaluating resources as to their appropriateness and suggesting novel materials for coding in the system.
3. Teachers are becoming more knowledgeable about a wider range of resource materials.
4. Teachers, parents, and supervisors are indicating that they receive more detailed information on skill performance for project students.

5. Overall computer operations seem to be running smoothly with turnaround time between classroom and computer averaging a week in length.

CURRENT STATUS OF PROJECT

During the 1979-1980 school year the program is being fully implemented and will serve 150 teachers and 2,400 L.D. students. Due to the nature of the data the decision has been made to input student information via NCS optical scan forms.

Efforts are being made this year to collect information on student performance, however, it becomes difficult to attribute student change information to a CMI program.

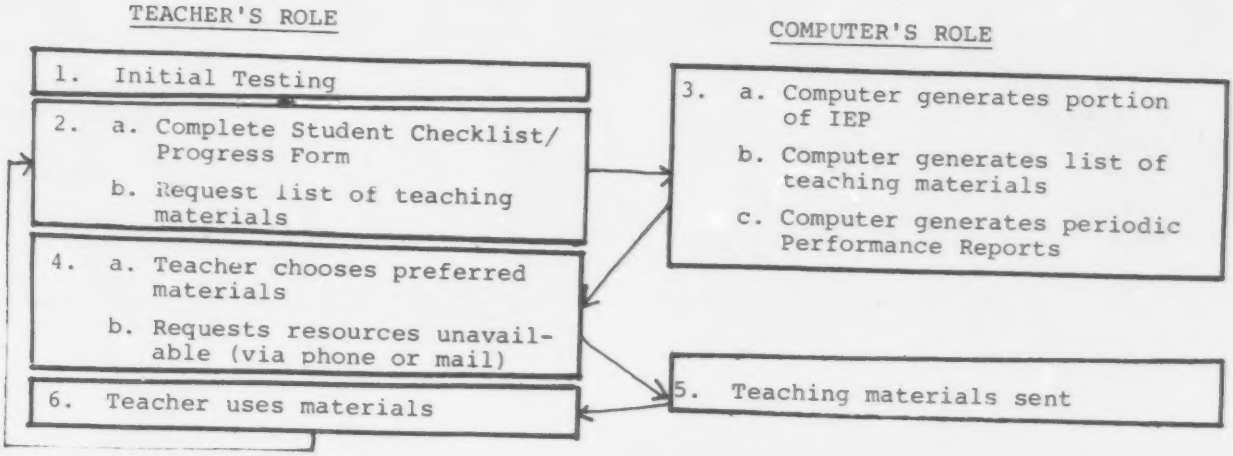
FUTURE PLANS

A real bonus for the program is its generalizability. It can easily be adapted to other exceptionalities as well as to the regular classroom because it is based on academic hierarchy in reading and mathematics. This may make it especially beneficial to regular classroom teachers trying to adapt programs for mainstreamed students.

In the future, the Allegheny Intermediate Unit is looking at the possibility of adding the Educable Mentally Retarded and the Learning Adjustment Programs to the computerized system. It may also be possible to service multiply-handicapped resource rooms and some mainstreamed students in district classrooms.

Attachment A

FLOWCHART OF IMPROVED INDIVIDUAL INSTRUCTION PROGRAM OPERATIONS



OPERATIONS IN STEP-BY-STEP FORM

1. Teacher does Reading and Math Assessment on student.
2. Teacher completes Student Checklist and Progress Form; makes requests for resource materials. Sends information to I.I.I.P. Center.
3. a. From Initial Assessment information, the computer generates a portion of an IEP.

   b. From information on Student Checklist and Progress Form, the computer generates a list of suggested resource materials. This list is sent to the teacher.

   c. The computer generates a Performance Report Form.
4. From the computer list, the teacher chooses those materials he/she prefers to use. If the material is unavailable to the teacher, he/she contacts the I.I.I.P. Center.
5. The I.I.I.P. Center sends the required resources.
6. Teacher uses the teaching materials.

   Next the teacher may:

   a. Request further resources for the same skills.
   b. Request a Mastery Test if remediation has been successful.
   c. Request resources for new skills.

   At the close of each marking period, the teacher may submit the Student Checklist and Progress Form to the I.I.I.P. Center with the student's progress marked for each strand/skill number appropriate. The teacher also indicates new strand/skills for which he/she requests resources. And the process begins again at Step 2.

Attachment B

****
ALLEGHENY INTERMEDIATE UNIT
EXCEPTIONAL CHILDREN'S PROGRAM
IMPROVED INDIVIDUAL INSTRUCTION PROGRAM
****
WED, JAN 23, 1980
SUGGESTED RESOURCE LIST FOR SUE WHITE

STRAND #002 STRUCTURAL ANALYSIS SKILLS
SKILL #035 SELECTS/USES CORRECT PUNCTUATION "."

STUDENTS WORKING ON THIS STRAND & SKILL:

00195 GEORGE WASHINGTON

RESOURCE #1
(00282) PRIORITY-YES LEVEL: PRIMARY-YES LOCATION: CLASSROOM-YES MASTER TEACHER-NO
SUPPLEMENTARY-NO INTERMEDIATE-YES REACH R.C.-YES IIIP LIBRARY-YES
PUBLISHER--BARNELL LOFT, LTD. SECONDARY-YES
RESOURCE INFORMATION--CAPITALIZATION AND PUNCTUATION, BOOK A, UNIT 7 (1972), REACH #50-039

RESOURCE #2
(00283) PRIORITY-YES LEVEL: PRIMARY-YES LOCATION: CLASSROOM-YES MASTER TEACHER-NO
SUPPLEMENTARY-NO INTERMEDIATE-YES REACH R.C.-YES IIIP LIBRARY-YES
PUBLISHER--BARNELL LOFT, LTD. SECONDARY-YES
RESOURCE INFORMATION--CAPITALIZATION AND PUNCTUATION, BOOK B, UNIT 7 (1972), REACH #50-040

RESOURCE #3
(00284) PRIORITY-YES LEVEL: PRIMARY-YES LOCATION: CLASSROOM-YES MASTER TEACHER-NO
SUPPLEMENTARY-NO INTERMEDIATE-YES REACH R.C.-YES IIIP LIBRARY-YES
PUBLISHER--BARNELL LOFT, LTD. SECONDARY-YES
RESOURCE INFORMATION--CAPITALIZATION AND PUNCTUATION, BOOK C, UNIT 7 (1972) REACH #50-040-01

RESOURCE #4
(00285) PRIORITY-YES LEVEL: PRIMARY-NO LOCATION: CLASSROOM-YES MASTER TEACHER-NO
SUPPLEMENTARY-NO INTERMEDIATE-YES REACH R.C.-YES IIIP LIBRARY-YES
PUBLISHER--STECK-VAUGHN CO. SECONDARY-YES
RESOURCE INFORMATION--LANGUAGE EXERCISES, SILVER BOOK, 1973, PP. 7, 9, 10, 15, 35, 93-96, 33, 25

INDIVIDUALIZED EDUCATION PROGRAM

GENERAL DATA

STUDENT - BROWN, CHARLIE PHONE - 777-0234

PARENT, GUARDIAN, OR OTHER _____

ADDRESS _____

ATTEMPTS AND RESULTS OF PARENTAL CONTACT(S)

PLEASE INDICATE WHEN AND WHAT TYPE OF PARENTAL NOTIFICATION WAS UTILIZED TO INVITE PARENTS TO ATTEND THE IEP CONFERENCE AND THEN INDICATE WHAT THE PARENT RESPONSE WAS TO EACH NOTIFICATION. PERSON(S) RESPONSIBLE FOR NOTIFICATIONS SHOULD INITIAL APPROPRIATE BOXES.

NOTIFICATIONS	DATE	LETTER	PHONE	HOME/SCHOOL VISIT	PARENTAL RESPONSE
FIRST					
SECOND					
THIRD					

IEP PLANNING TEAM

THE FOLLOWING PERSONS HAVE PARTICIPATED IN THE INDIVIDUALIZED EDUCATION PROGRAM PLANNING CONFERENCE:

NAME	TITLE
GEORGE WASHINGTON	L.D. TEACHER

SCHEDULE

DATE OF IEP CONFERENCE _____
DATE(S) OF ANNUAL REVIEW ---- 09/09/79
DATE OF LAST RE-EVALUATION -- 09/06/80

GENERAL DATA:

STUDENT: BROWN, CHARLIE BIRTHDATE: 02/02/65 PHONE: 777-0234

PRIVATE SCHOOL _____

SCHOOL DISTRICT: BABCOCK BUILDING: PINE JR. HIGH _____

REGULAR EDUCATION PARTICIPATION: THE STUDENT WILL, AT THIS TIME, PARTICIPATE IN REGULAR EDUCATION: ALL ( ), MOST ( ), PART ( ), OR NONE ( ) OF THE TIME AT THE _____ GRADE.

SPECIAL EDUCATION ASSIGNMENT(S):	PROJECTED DATES BEGINNING	ENDING	SPECIAL MEDIA/MATERIALS
LEARNING DISABILITY _____	04/05/72	ONGOING	_____
_____	_____	_____	_____
_____	_____	_____	_____

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RELATED SERVICES:

TRANSPORTATION _____	_____	_____	_____
REGULAR ( )			
PHYSICAL EDUCATION ADAPTIVE( )	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

PRESENT EDUCATION LEVELS

WIDE RANGE ACHIEVEMENT TEST SCORES:

READING WORD RECOGNITION: 06.03 GRADE LEVEL (04/79)

SPELLING: 08.02 GRADE LEVEL (04/79)

ARITHMETIC: 06.03 GRADE LEVEL (04/79)

COMPUTER GENERATED PORTION - IEP STUDENT: BROWN, CHARLIE SCHOOL YEAR: 1979/1980

INSTRUCTIONAL AREA: MATH
ANNUAL GOAL: NUMBER SEQUENCING SKILLS

EDUCATIONAL TASKS--SHORT TERM OBJECTIVE	EVALUATION PROD/COND	SUCCESS CRITERIA	PROGRESS
RECOGNIZES/COMPLETES NUMBER PATTERNS	APPROP. MASTERY TEST 102/007-102/010	TEACHER EVALUATION: AT _____ ACCURACY:	
COPIES/ORGANIZES NUMBERS CORRECTLY	APPROP. MASTERY TEST 102/011-102/020	TEACHER EVALUATION: AT _____ ACCURACY:	
	APPROP. MASTERY TEST	TEACHER EVALUATION: AT _____ ACCURACY:	
	APPROP. MASTERY TEST	TEACHER EVALUATION: AT _____ ACCURACY:	
	APPROP. MASTERY TEST	TEACHER EVALUATION: AT _____ ACCURACY:	

INSTRUCTIONAL AREA: READING
ANNUAL GOAL: PHONIC ANALYSIS SKILLS

EDUCATIONAL TASKS--SHORT TERM OBJECTIVE	EVALUATION PROD/COND	SUCCESS CRITERIA	PROGRESS
IDENTIFIES IRREGULAR VOWEL COMBINATIONS	APPROP. MASTERY TEST 001/163-001/170	TEACHER EVALUATION: AT _____ ACCURACY:	
IDENTIFIES IRREGULAR PHONETIC PARTS	APPROP. MASTERY TEST 001/171-001/177	TEACHER EVALUATION: AT _____ ACCURACY:	
IDENTIFIES DIPHTHONGS	APPROP. MASTERY TEST 001/182-001/190	TEACHER EVALUATION: AT _____ ACCURACY:	
IDENTIFIES SILENT LETTERS B, G, K	APPROP. MASTERY TEST 001/191-001/193	TEACHER EVALUATION: AT _____ ACCURACY:	
	APPROP. MASTERY TEST	TEACHER EVALUATION: AT _____ ACCURACY:	

Attachment D

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ALLEGHENY INTERMEDIATE UNIT
EXCEPTIONAL CHILDREN'S PROGRAM
IMPROVED INDIVIDUAL INSTRUCTION PROGRAM

****

PERFORMANCE REPORT FORM

STUDENT: BROWN, CHARLIE
TEACHER: GEORGE WASHINGTON
SCHOOL: PINE JR. HIGH
SCHOOL TERM: 1979/1980
DATE: AUG. 24, 1979

RECORD OF ATTENDANCE

1ST PERIOD _____
2ND PERIOD _____
3RD PERIOD _____
4TH PERIOD _____
5TH PERIOD _____
6TH PERIOD _____

PERFORMANCE CODES

M--MASTERY OF SKILL. NO FURTHER GRADES WILL BE GIVEN FOR THIS SKILL.
P--PROGRESS HAS BEEN MADE ON SKILL.
N--NEEDS REMEDIATION
S--STUDENT HAS REACHED FRUSTRATION LEVEL. INSTRUCTION WILL BE STOPPED TEMPORARILY AND RESUMED AT A LATER DATE.
R--STUDENT HAS REGRESSED FROM PREVIOUS PERFORMANCE LEVEL. INSTRUCTION MUST BE RESUMED.

LISTED BELOW ARE THE MAJOR GOALS AND SKILLS WITH WHICH THIS STUDENT HAS BEEN WORKING:

	MASTERY SCORE	RATING PERIODS 1	2	3	4	5	6
MAJOR GOAL: 102-NUMBER SEQUENCING SKILLS							
SKILL:							
008-RECOG/COMPLETE NUMBER PATTERN-FRWD ODD	100%	P	M				
009-RECOG/COMPLETE NUMBER PATTERN-BDWRD EVEN		P	M				
MAJOR GOAL: 103-MATHEMATIC PROCESSES							
SKILL:							
004-ADDITION-ASSOCIATIVE CONCEPT		P	R				
005-ADDITION-COMMUTATIVE CONCEPT		N	S				
MAJOR GOAL: 104-FRACTION SKILLS							
SKILL:							
001-RECOGNIZES AND NAMES FRACTION: ONE HALF	80%	P	M				
002-RECOGNIZES AND NAMES FRACTION: ONE THIRD	100%	P	M				

Attachment E

EXCEPTIONAL CHILDREN'S PROGRAM
IMPROVED INDIVIDUAL INSTRUCTION PROGRAM

TEACHER EVALUATION OF COMPUTER GENERATED PORTION OF THE IEP

ITEM	N	%	N	%	N	%	N	%	N	%
	Excellent		Good		Fair		Poor			
1. My overall reaction to the Computer Generated Portion of the IEP is:	8	80.00	2	20.00	0		0			
	Yes		No		Don't Know					
2. Was time saved in doing the IEP because you used the Computer Generated form?	10	100.00	0		0					
	1/2 hr.		3/4 hr.		1 hr.		1-1/2 hr.		3 hr.	
If yes, estimate the amount of time saved per IEP.	2	25.00	2	25.00	1	12.50	2	25.00	1	12.50
	Yes		No		Don't Know					
3. Was there time saved by having the computer generate vital statistics already in the data base? (This is the information that appears on pages 1 and 2 of the IEP.)	10	100.00	0		0					
	Yes		No		Don't Know					
4. Was there time saved in having specific mastery tests listed for each skill on the IEP?	9	90.00	0		0					
	Very Clear		Clear		Hard to Understand					
5. How understandable is the format of the Computer Generated Portion of the IEP?	7	70.00	3	30.00	0					
	More Complete		Just As Complete		Not As Complete					
6. How complete do you feel the Computer Generated form is as compared to the handwritten IEP?	6	60.00	3	30.00	1	10.00				

Teacher Evaluation (cont'd)

ITEM	N	%	N	%	N	%	N	%	N	%
	Yes		No		Don't Know					
7. Does the Computer Generated Portion allow for adaptability if other skills need to be added to the IEP?	10	100.00	0		0					
	Very Efficient		Efficient		Uncertain		Inefficient		Very Inefficient	
8. How efficient is the Computer Generated Portion of the IEP?	7	70.00	3	30.00	0		0		0	
	Very Complete		Complete		Uncertain		Incomplete		Very Incomplete	
9. How complete is the Computer Generated Portion of the IEP in terms of adequately covering reading/math skills and evaluation conditions?	5	50.00	5	50.00	0		0		0	
	Yes		No		Don't Know					
10. Do you feel more instructional time was available because you used the Computer Generated form?	9	90.00	0		1	10.00				

Attachment F

EXCEPTIONAL CHILDREN'S PROGRAM
IMPROVED INDIVIDUAL INSTRUCTION PROGRAM

PARENT QUESTIONNAIRE ON THE COMPUTER GENERATED PORTION OF THE IEP

ITEM	N	%	N	%	N	%	N	%
	Excellent		Good		Fair		Poor	
1. My overall reaction to the Computer Generated Portion of the IEP is:	24	40.68	28	47.46	5	8.47	2	3.39
	Yes		No		Don't Know			
2. Is the Computer Generated Portion of the IEP easy to understand?	51	86.44	5	8.47	3	5.08		
	Yes		No		Don't Know			
3. Is more conference time with the teacher available to you because most of the objectives are already on the form?	51	86.44	0	0.00	8	13.56		
	A Lot		Some		A Little		None	
4. How much time do you feel the Computer Generated Portion of the IEP saves for the teacher?	53	89.83	5	8.47	1	1.69	0	0.00
	More Complete		Just As Complete		Not As Complete			
5. How complete are the skills on the Computer Generated Portion of the IEP as compared to the handwritten IEP?	17	28.81	40	67.80	2	3.39		
	Yes		No		Don't Know			
6. Does the Computer Generated Portion allow for adaptability if other skills need to be added to the IEP?	56	94.92	1	1.69	2	3.39		

will be available by the time of this meeting. However, such systems require more memory than is really essential for a classroom system, and consequently they are expensive (at current prices about double for the microcomputer). Therefore we chose to write a multi-user system in which users simultaneously could carry out one of a limited number of tasks. That is, we wrote a multi-user CAI system which was extended to include a limited version of BASIC and a text editor in addition to the author language.

The CAI materials are written in the author language, COMMON PILOT. We have described COMMON PILOT in detail in a talk at a previous ADCIS meeting (1) and elsewhere (2), so we will not repeat that description here. The 6809 implementation incorporates all the latest features of COMMON PILOT including graphics, file input and output, simplified generation of random integers, and optional use of the space after the op code colon. COMMON PILOT continues to be the most widely implemented author language for micros, with a number of additional implementations and courseware packages completed in the last year. Because the COMMON PILOT interpreter includes an expression processor which handles a complete set of numerical and string operators and functions it was fairly straightforward to add a limited BASIC based on this expression processor to the interpreter. We call this BASIC student BASIC because it includes enough to introduce students to the fundamental ideas of computing, for example, variables, strings, arrays, loops, conditionals, and subroutines. Student BASIC includes the operations DIM, END, FOR ... NEXT, GOSUB, GOTO, IF ... THEN, INPUT, LET, REM, RETURN, and STOP. We plan to extend this list somewhat if interest warrants. We also have added a screen oriented editor to the interpreter. The screen functions as a 16 line window which can be shifted forward and backward through a text file. All editing is done on the bottom line of the screen. The cursor is controlled in effect by the four arrow keys on the terminal; the up and down arrows shift the 16 line window; left and right actually move the cursor. Over-typing replaces characters. Insert opens space for new characters; delete removes characters. Space for new lines requires a single key stroke. Files created or edited in this way may be saved as text files on either disk drive. The COMMON PILOT and Student BASIC interpreter accepts text files as programs, so the editor can be used to prepare programs in both languages.

The hardware requirements for this system are rather modest. The major components of a four terminal system are

SwTPC / 09 Computer (56K)
Dual 8" Disk (2.5 M byte)
4 CT-82 CRT Terminals

which cost (in combination with minor additional, but needed components) approximately $7,400, including terminals. Although COMMON PILOT is not hardware specific, this implementation is. In addition to the need to communicate with the DOS the graphics instruction in COMMON PILOT and a number of the text editor operations are specific to the terminal. There are a number of other software packages available for this hardware including a number of very powerful versions of BASIC. Those BASICs accept text files as BASIC programs, so the hardware can be used in multi-user made to create programs, which programs can be run subsequently in single-user mode under the more powerful interpreters and/or compilers.

At this writing we have installed three of these systems in classrooms. At the same time we have begun a training program for the teachers in the school. The training program includes all the science and mathematics teachers in the school; it lasts for four weekends. It would be premature to make sweeping evaluations of either the system or the training program at this writing; by the time of the meeting we will be able to say more. Thus far the system has met or exceeded expectations and has generated real enthusiasm in both the students and the teachers. Teachers in the training program, who were not the instigators of the project, were working on materials for their own classes and discussing the acquisition of more hardware by the end of the second training session. This is much faster than we've been able to progress in previous sessions on other systems; it is in large part due to the integration of the text editor with the COMMON PILOT interpreter. Student use expanded instantaneously to keep the eight terminals in constant use. Our next step is to introduce courseware which will interest teachers outside the math-science area.

In summary we have developed and have in use a powerful classroom system which is robust and simple. By writing multi-user system software we have cut the per-station cost below $2,000 while providing the language, storage, and graphics capabilities of systems costing at least 50% more. We think that this approach will prove to be very attractive in a variety of school situations.

MICROS IN THE CLASSROOM

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The microcomputer will produce a revolution in the classroom. Two years ago that statement would have sparked a debate among the CAI advocates and blank looks among the teachers; now it is old hat. However, if the statement is going to be proven to be true, we who believe that micros represent the future of CAI must deliver systems and software which will initiate the revolution, and we must do it now - before game machines and personal computers miscolor the public's and the teacher's conception of what teaching with a microcomputer can be. No revolution will be started using hardware and systems software which requires one or more steps backward from large computer systems. Any system worthy of serious consideration for the classroom must combine the virtues of good mini-based and maxi-based systems (e.g. good author language, disk storage, full computational power) with the advantage of micro-based systems (e.g., graphics, flexibility). In this paper we describe such a system which also offers the advantage of economy.

A classroom computer system should provide three types of service: top quality CAI, numeric and string manipulation using a standard computational language, and text editing. This audience hardly needs to be convinced that delivery of top-quality CAI with good response time is an essential requirement for a classroom system. A traditional computing language is useful for several reasons. Some useful CAI materials - mainly complex simulations - are better written in such a language; some data analysis is handled more easily in computational languages than in author languages. The main reason is that many classroom systems are likely to be used in part to teach programming at the beginning level. The text editor is needed for the creation of and editing of programs in the author language and in the computational language (in some cases) as well as in its own right. An introduction to text editing is useful for many students, especially those in various business courses. As used in the typical classroom, none of these applications makes heavy demands on a CPU. Two of them, the CAI and text editings really require a disk. The combination of an underutilized CPU with the requirement for a disk - which is relatively expensive - makes the possibility of a multi-user system an attractive alternative.

At this point we should clarify the distinction between multi-user and multi-tasking systems. Multi-user systems allow multiple users simultaneously to run programs written in a common language; multi-tasking systems allow multiple users simultaneously to run programs written in any of the languages implemented on the computer. Obviously a multi-user system is easier to implement than a multi-tasking system. The economy of using a single microcomputer to serve several users is obvious, and a few manufacturers have offered multi-user systems for a number of years. At least two multi-user BASIC systems are available, and one multi-user author language is available. None of these systems have gained popularity, mainly because the CPUs were not underutilized and in practice response times were too long. Within the last year a new generation of microprocessors has been introduced, and these new microprocessors have internal features which make multi-user (and multi-tasking) systems software much more efficient. Our system is based on the first of these to reach the market in volume, the Motorola 6809.

Multi-tasking systems are under development for the 6809, and they probably

References

1. "Champagne Quality CAI on a Beer Budget," George Gerhold and Larry Kheriaty, ADCIS Proceedings 1979, p. 901.

2. "Common Pilot Reference Manual," Larry Kheriaty and George Gerhold, Western Washington University, 1978.

205A

TOUCH TONE CMI

Harold F. Rahnlow

The American College

ABSTRACT

Many adults live and work in environments which are distant from university or corporate educational facilities. For these individuals, however, it is critical that career-long education and training be available. This paper describes telephone-assisted computer-managed instruction, a proposed technique for bringing selected benefits of a computer-managed instruction system to individuals in their home or place of work at a low price. The proposed technique would combine computer and communications technology using a touch tone telephone as the student terminal.

BACKGROUND

The majority, if not all, current computer-based instructional systems make the assumption that students can be grouped together geographically in order to make use of relatively expensive terminals. Although this may seem contrary to the touted geographic flexibility of computer-based education it is not. Computer-based education does allow great geographic flexibility, but subject to the availability of terminals. Even with the dramatic introduction and proliferation of microcomputers, the cost of an individual terminal is still several hundred dollars. For many applications, this cost is reasonable, for other applications it is not.

Consider the adult living some distance from a college campus or corporate training center. It is unlikely that the individual will have access to a terminal which would interface with a large scale computer-based educational system. Given this handicap, is it still possible to provide the individual with the advantages of computer-based education?

Computer-managed instruction is predicated on the assumption that the computer provides a management function and that the instructional media used for learning are not dependent upon the computer. Given the fact that the computer is to be used as a management tool, what are the bare bones necessities for computer-managed instruction? First, of course, there must be a computer with the appropriate softwear for managing instruction. Second, there must be a input-output device for the student, instructor, or course developer, and third, there must be a mechanism for interfacing the student, instructor, or course developer input-output device with the computer.

OVERVIEW OF THE SYSTEM

Telephone-assisted computer-managed instruction (TACMI) is technology designed to bring the benefits of computer-managed instruction to the individual student in his home or place of business without the necessity of employing expensive computing terminals. The following discusses the second and third points with respect to a bare bones CMI system while assuming the existence of the first.

To implement TACMI the student uses a study guide and study materials which may be in any medium. At appropriate points in the study guide, short objectives-based tests are presented. Students would complete the test in the study guide and then use a telephone to interface with a computer. Using the touch tone pad of a telephone, the student enters appropriate indentification and security information to "sign-on" the system and then keys in answers to test questions. The computer simultaneously scores each item, and upon completion of all items, responds to the

student with voice messages indicating areas of mastery, areas of nonmastery and the appropriate course of action for the student to take with respect to further study.

On a periodic basis, summary reports would be generated for the student and for those directly involved in monitoring his study progress. For example, students studying independently in a non-traditional higher education program could have reports sent to themselves and to their mentor. Trainees at remote locations in a business environment might have reports generated for their regional manager as well as for the home office training director. Such reports would not need to give data on specific items mastered, but would rather indicate general progress and warn of negative deviations from a planned course of progress. In addition, these reports could be distributed through the mail, or over the phone to phone receivers or printing devices. In addition, periodically, or upon the completion of a course, item analysis and summary data could be generated for instructional developers responsible for course development and for quality control of courses.

Although the concept of TACMI grew from a consideration of the individual student, it could also be incorporated into a conventional classroom environment or to enhance innovations such as the Construct Lesson Plan Design advocated by Langdon. (Langdon, 1978). Using the Construct Lesson Plan, students complete their study and take a short test prior to coming to class. The first class activity is to use an inexpensive color wheel response device to transmit student responses on each question to the instructor. The instructor then uses predesigned material to construct a lesson that responds to the needs of the group. Using TACMI students could provide their input from their homes, offices, or dormitories thus allowing the computer to summarize the results and saving in class time.

The component technology for developing TACMI currently exists and, in fact, is in general use. General computer-managed instruction systems have existed in various forms for over a decade. (Baker, 1978). Many banks currently use telephone activated bill-paying systems which allow the customer to pay bills and receive feedback on account status. Rather than being a radical proposal, TACMI is a unique combination of existing techniques and technology. While theoretically possible, a major question concerning TACMI is acceptance by instructors and students. The American College and AT&T are currently conducting a market analysis of the potential for TACMI.

CAUTIONS

A number of potential problems need to be addressed in the design and subsequent development of TACMI. An important class of problems relates to the computer and telephone technology necessary to implement the project and the resulting federal regulations which would have to be attended to. This class of problems is not discussed in this paper.

The primary response to the student is immediate and auditory, but would most likely be quite short. It may be that students would wish to wait longer for a response and receive a more detailed response in a printed format through the mail. In a project carried out by the Open University of Great Britain, approximately one-third of the students opted for feedback to testing via the conventional mails rather than through computing terminals. (Cooper, 1979).

As far as a computer-based education system is concerned, TACMI is not a rich environment. Although it does have an immediate auditory component, it does not have the hard copy features or visual displays normally associated with computer-based education. Moving up to more sophisticated terminals or to interfacing with microcomputers would allow hard copy or visual displays, however, it would also dramatically escalate the cost. Likewise, Viewdata offers many exciting, albeit vastly more expensive options. Viewdata is an information service from the British Post Office which enables people to call up information over their telephone line and have it displayed on their television sets. General Telephone and Electronics Co. has the right to market Viewdata in the United States.

The home computer could offer a significantly richer educational environment even though the costs are likely to be higher. Two significant points, however, need to be addressed before going to the home-based microcomputer route. First, and most important, individual computers used in isolation do not allow for continual monitoring of student progress. Experience suggests that this lack of monitoring may be significant in the high attrition rate experienced by virtually all institutions engaged in teaching at a distance. Second, one must analyze the objectives of a computer-managed instruction system and determine the essential components for the construction of that system. Computer features which are nice, but not necessary, cannot be tolerated in a bare bones CMI system.

CONCLUSION

It would appear that TACMI could be of significant benefit to educational institutions and businesses which have a need to engage in teaching at a distance. It is also feasible that such a system could be of benefit to homebound individuals.

Because of the rapid developments in technology it may be that TACMI would only be an interim system until microcomputers, Viewdata, video disc, and similar technology are prevalent in the home. However, even if this were to be the case, the benefits which would accrue to students in the interim and the experience that would be provided to the developers of other technologies, could well be worth the investment.

REFERENCES

Baker, Frank B. Computer Managed Instruction, Educational Technology Publications, Englewood Cliffs, NJ 1978.

Cooper, Aldwyn J.R., "A Preliminary Report on the Development and Application of CICERO, an Interactive and Batch Computer Assisted/Managed Learning System Developed for Use in the Distance Teaching Environment"

Langdon, Danny G. The Construct Lesson Plan, Educational Technology Publications, Englewood Cliffs, NJ 1978.

COURSEWARE DEVELOPMENT IN AN INDUSTRIAL ENVIRONMENT

Patrick J. DeSabia and Thomas M. Schaefges

Courseware Applications, Inc.

ABSTRACT

The team approach to courseware development has been found to be an efficient system to produce CAI courseware in a production environment. Each member of the team performs one of five main tasks. The function, input materials, and output materials of each team member must be carefully defined to insure production. The authors discuss these points.

Much has been written about the courseware design/development process. Most of the material, however, emphasizes the instructional technology used for general course design and evaluation, leaving the actual development process with only a few paragraphs. Our goal is to outline the development process as used in a production environment and to propose a structure and organization for the production group. Unless a competent, efficient development group is available, even the most meticulous design effort will not produce good courseware.

The goal of the development group is to implement the plan specified by the course designers. For this discussion, we will assume that the course design work has been completed and that the basic lesson design and lesson-objective assignment has been done. The course designer is not out of the picture yet, however. During the development process, the course designer must periodically check to be sure that the development meets the course specifications. The development group, if they are to do a good job of implementing the course, must have regular access to the course designer to resolve problems. We have found it useful for the designer to meet with a representative of the development group before the development starts to be sure the course design specifications are communicated to the developers clearly and to be sure that any initial questions are answered.

There are five roles in the development team: subject matter expert (SME), lesson developer, CAI programmer, text editor, on-line quality assurance monitor (QA monitor). Of course, if CAI is not the only media additional media-specific functions must be added, but for our purposes we will concentrate on the production of CAI lessons. The work flow is controlled by a manager whose role is to schedule each function to assure the optimum work flow as well as monitor the production effort to assure time and cost constraints are met. We have found it better if each person in the development group performs only one role with one exception. Our experience dictates that the lesson developer should also do the text editing. Content errors or changes introduced by the programmer can be caught as the text is being checked for wording, spelling, punctuation, and grammar. The duality, of course, requires that one of the lesson developers' qualifications is to be able to function as a text editor. We have found this qualification easy to find in the type of person we select as a lesson developer.

Now let us examine in detail the work flow for a typical CAI lesson. After the course design specifications are complete, production of a lesson begins with the specification of the content, which is done by a subject matter expert (SME). The SME would be familiar with teaching the subject to the intended audience for the course, as well as having a thorough knowledge of the subject itself. Our experience has shown that an SME without

both these qualifications could unknowingly generate inaccurate or inappropriate material.

The SME begins by compiling a list of content sources to draw upon when specifying the content for a lesson. Using a set of entry behaviors and behavioral objectives for the lesson (produced during the course design), the SME then generates a content narrative. The purpose of the narrative is to communicate to the developer all the content a student must learn to reach the stated objectives for the lesson. The content narrative can take whatever form is most expedient for a given course: for a course designed to accompany an existing text, page references to that text may be sufficient; if the course is highly technical the SME might provide a written explanation of the content. It is essential that the content narrative contain all the information for each objective in the lesson. The developer should be able to develop the lesson without having to search out any further content.

At this point, the lesson developer comes into play. Using the content narrative, the lesson developer is responsible for producing a CAI lesson to teach the stated lesson objectives. To accomplish this task, the developer needs to first become acquainted with the material to be taught in the lesson. A well-done content narrative will provide this information for the developer. The developer then begins the job of actually creating the material the student will see on the screen; this result is called the programmable-ready material (PRM). PRM contains all the text, graphics, exercises, quizzes, sequencing instructions and any other specifications the programmer will need to actually implement in the lesson. In short, the developer's job stops just short of the actual programming. During this phase, the developer should have ready access to the SME to immediately resolve any questions on content. When the PRM is finished, the SME should then read through it to assure that the content is accurate.

In order to produce the most effective instruction, the developer must be familiar with the particular CAI system the lesson will be used on. To this end, we have found it to be particularly effective to begin developer training with a short course in programming in the CAI language to be used. The developer can thus become familiar with the capability of that particular system. In addition, it aids communication later between the developer and the programmers.

Once the developer has prepared the PRM, it is passed to the CAI programmer. The PRM contains all of the information the programmer needs to put the lesson on the computer. PRM is usually organized as a frame by frame description of the lesson, with the branching for each frame specified. Thus, the programmer's only reference for the lesson is the PRM. The programmer is given the freedom to make minor changes in the developed lesson for the sake of programming ease, but all changes must be cleared with the developer. It is clear that the developer's training must include programming on the target CAI system to insure that the PRM does not specify any unreasonable frames.

It may seem better to simply let the developer do the programming of the lessons and do away with the separate programmer function entirely. We have found that separation of roles is more efficient for two reasons: 1) the developers are required to have an advanced degree in a branch of education while the programmers are not, and 2) it is better to develop unique specialties well than to allow the roles to be combined with mediocre results. The most important of the reasons is the second. The skills required for developers are much different than the skills required of a programmer. Neither one is more important than the other, but candidates for positions with the team will usually have a greater aptitude for one position than for the other. We choose to take advantage of this and develop skills in one area as well as possible.

When the programmer has completed a lesson, it is sent to the text editor for review of spelling, punctuation, and grammar. It is possible to have the developers do the test editing (assuming they have had the necessary training) and include a review of the lesson text to be sure it matches the PRM specifications. The text editors specify corrections on a hard copy print of the lesson, if possible, and the programmer checks the lesson to be sure the formatting has not been upset by the editing changes. (Added or deleted characters or words cause changes in line lengths.)

After all of the editing has been completed, a quality assurance (QA) checker examines the lesson as a student would and checks for correct functioning. The QA check will also uncover any programming errors and point out weaknesses in the lesson development. Comments generated by the QA check are used by the developer to modify the lesson and by the programmer to correct errors. The cycle of QA check-programmer/developer--QA check continues until all of the known problems are fixed. At this point the SME is called back to review the final lesson as a last check on

content accuracy. Changes suggested by the SME are sent to the developers for consideration and then on to the programmer if it is determined to be appropriate to use the suggestions.

Once a lesson is finished it must be sent to the "consumer" or client for final approval. Once again, the developer is given the suggested changes to be sure the ones being implemented will fit the style of the lesson. Whenever a major change occurs in a completed lesson it is sent back to the quality assurance checkers to be sure no new errors have been created.

We have discussed the entire process of developing a lesson starting after the course design has been completed through to the customer approval. The system we have outlined has worked well in our production environment, and we are sure it could be adapted to any situation with only minor modification.

A MODEL FOR GENERATIVE HARMONIC DICTATION

W. Kenton Bales
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In recent years, advanced information technology has led to important developments in computer conducted drill and practice. Computers can monitor drill and practice efficiently and effectively, and in the process motivate students and trainees (Licklider, 1979). Instructors in music theory have applied these developments to many types of drill in aural training, including the ability to label chordal entities with a set of pre-determined symbols (harmonic dictation). Most drill and practice techniques have been implemented through lessons that contain a fixed number of musical examples. If the students practices on one lesson long enough, he may be able to memorize the correct responses, and therefore cripple the lesson's primary purpose. A method of generating musical examples that are different each time is desirable if lessons are to be truly effective.

Previous research in generative harmonic dictation has been primarily linear or Schenkerian in approach (Frankel, 1975, Keiler, 1977). However, if a computer is to generate progressions in a linear fashion, great amounts of temporary storage must be available, and complex parallel processing techniques should be implemented. A non-linear analytical technique similar to the chord symbol analysis that students might use is one method available that encourages the implementation of effective generative algorithms. The present paper describes a method for developing generative drill and practice for harmonic dictation.

In Figure 1, four simultaneous melodic lines combine to create a configuration which is familiar to most first semester theory students. Each line follows traditionally accepted voice leading principles common to primarily tertian tonal music from the eighteenth and early nineteenth centuries (the common practice period). Students are asked to perform a

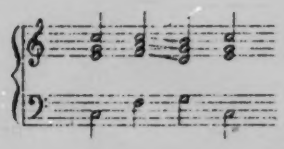

Figure 1.

variety of tasks when confronted with such an example, ranging from identifying cadential formulae to writing chord symbols and all four melodic lines. A traditional analysis of such an example might I, IV, V, I. This analysis may be acceptable from students, but in order for a digital sound synthesis system to reproduce this example, much more information is necessary. The most common method for encoding requires the author of the lesson to enter a set of symbols for each note from a computer terminal. This method is tedious and consumes large amounts of computer memory. The number of examples possible within a given lesson as well as the size of an aural skills package may be severely limited by the amount of available magnetic storage, particularly if the system is micro- or mini-computer based. A generative method of producing aural exercises not only saves encoding time for the author, but also frees valuable computer memory so that it can be used for other purposes.

Certain consistent parameters describe chords and their progression in the common practice style. For example, three conjugations (root relationships as discussed by Eschman, 1965) describe all root motion;

root position triads almost never retain the same soprano position when the roots of the chords are a fifth apart; when the roots of two chords are a second apart, the upper three voices move in contrary motion to the bass; etc.

Progressions which are considered to to be representative of the common practice style can be generated by using a circular linked list (Elson, 1975). In such a data structure, the progressions in Figure 1 appear as in Figure 2, where each of four nodes (chords) has a pointer associated with it which indicates the value

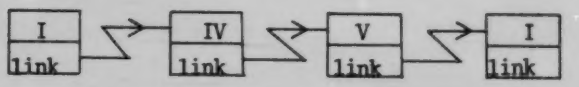

Figure 2.

of the next node (chord). Each node contains score code which describes a chord with attributes from the common practice style as described above. Chord progressions may be generated by choosing a single symbol which represents an entire chordal entity. Linked list structures generate harmonic dictation examples in a manner similar to that considered by current research in linguistics (Bates, 1979).

Restraints are placed on the generator so that the limited vocabulary of the common practice (and freshmen) will be simulated. Part writing principles as defined by Robert Ottman in his Elementary Harmony provide bases for most restrictions imposed on the program. Triads may progress freely to one another within the confines of a tree, similar to that described by Abbot, 1978. Figure 3 represents the acceptable common chord progressions. Tonic may follow any chord and may interrupt any common chord progression. Triads may appear in root position with the root, third, or fifth in the soprano.

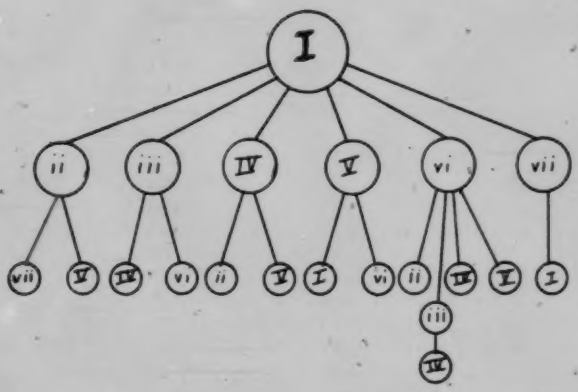

Figure 3.

Each node of the linked list must be expanded to include several pointers which allow complex branching capabilities in order to implement progressions which can be derived from Figure 3. Figure 4 is an example of how such a node might appear as a member of a file. In actual practice, many pointers are associated with each node.

1)	2)	3)	4)		5)
2	I	4GD 3G 2E CUH %E	3	5	-1

1) Number of the node
2) Correct answer string
3) Score code (for Musor)
4) Pointers to other nodes
5) End-of-node flag

Figure 4.

The program always begins at node 1, which contains score initialization information and pointers to all possible starting chords. After the first pointer is chosen, using a random number generator, the corresponding node is located. The program reads the correct answer and concatenates it into an answer string. The score code is read into the Musor instrument (Bales, Hamilton and Scott, 1978) and stored until a performance is initiated. The random generator picks another number and the process is repeated until a node is reached that carries an end-or-progression flag. The score code in this node includes the play command, and the entire progression is performed for the student. His answer is checked against the concatenated answer string, and action is taken in response to his correct or incorrect entry. Default values and features of the AMUS language (Hamilton and Scott, 1978) make rapid score entry possible, and the transposition function allows all code in the file to be stored in a single key and transposed to any other key at random.

Previous research has shown that certain chord progressions are significantly more difficult for students than are others (Hofstetter, 1978). Weighting is done in order to present more drill on problem areas and to simulate more closely common practice procedures. This weighting may be accomplished either in the driving program or in the file. (Two pointers to a single node double the possibility of that node being chosen next.) Weighting is also helpful in creating chord progressions that are of appropriate length, since the

generative algorithm will produce progressions of varying length. At any time, program control may specify the length of a progression.

Despite the fact that computer time and equipment are becoming more economical, the amount of available storage and the efficient execution of programs still harass the author of drill and practice lessons. Linked list processing, as applied here to drill and practice in harmonic dictation, appears to be a flexible, computationally efficient method of generation. Current research at North Texas State University, as well as at other institutions, includes development of similar programs for rhythmic, intervallic, and melodic dictation. Implementation of the linked list technique in software using high speed mini- or even microcomputers (such as the APPLE II) is feasible. Linked list processing can be a significant factor in the development of powerful generative computer-based learning packages when programs and files are carefully constructed.

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COMPUTER-BASED RECOGNITION OF PERCEPTUAL PATTERNS IN CHORD QUALITY DICTATION EXERCISES

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ABSTRACT

During the 1977-78 academic year an experiment was conducted with eighteen freshman music majors for the dual purpose of measuring student achievement in the GUIDO chord quality program and of determining the overall pattern of student responses to chord quality dictation exercises. A two-part test was developed to measure student achievement on chords in close position and on chords in open position. This test was administered three times: first, at the beginning of the first semester before training began; second, at the end of the first semester after training on chords in close position but before training in open position; third, at the end of the second semester after training on chords in open position. As one would expect, correlated t-test comparisons of scores on these tests showed that significant learning gains occurred on the basis of chords in close position during the first semester and on the basis of chords in open position during the second semester. However, additional significant increases were noted on the basis of chords in open position during the first semester and on the basis of chords in close position during the second semester. An important transfer mechanism might exist between training on chords in open and close positions. Analysis of student responses made on the third set of tests led to the identification of five principles of chord-quality confusions. First, there are three main clusters of student responses which were due to the almost exclusive confusion of chords by their inversions. Second, the augmented and diminished chords were almost always confused with each other, and they were rarely confused with major and minor chords. Third, the role of expectations in student perception was demonstrated with regard to the root position diminished chord which was almost always confused with its more common first inversion. Fourth, the major chord in root position was found to be much more difficult to identify than is generally believed. In close position five other chords were easier to hear, and in open position three chords were easier to hear. Fifth, the most difficult chord to hear was shown to be the minor chord in first inversion, which in open position is confused only by inversions, but which in close position is confused with augmented and diminished chords. Given the small sample size used in this study (N=18), independently administered replications of this experiment should seek to determine whether the perceptual patterns found in this sample will also occur in other groups.

INTRODUCTION

During the summer of 1977, work was completed on a computer program which teaches the aural identification of chord qualities in a competency-based[1] format. Part of the University of Delaware's GUIDO system, the chord quality program uses a drill-and-practice technique in which the computer plays chords on a digital synthesizer and then asks

[1] Competency-based education is a type of mastery learning as exemplified by Bloom (1976). The term criterion-based is also used to denote this type of mastery learning.

the students questions about what they hear. This technique takes advantage of both the interactive graphics and the touch-sensitive input of the PLATO system. Figure 1 shows a sample screen display from the chord-quality program.

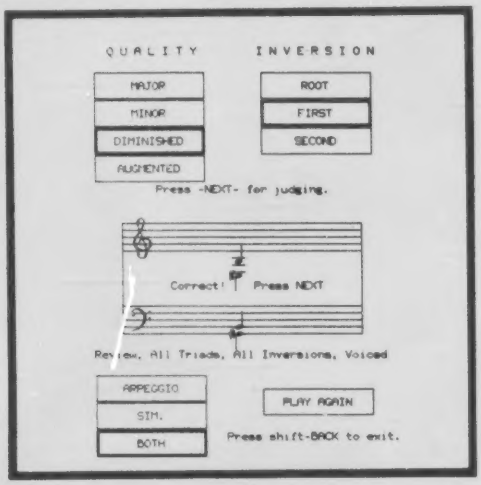

Figure 1. Sample display from the GUIDO chord-quality program, by Rosemary Killam, Fred Hofstetter, and Michael Larkin. Copyright © 1977 by the University of Delaware PLATO Project.

At the top of the screen are two columns of touch-sensitive boxes with which the students indicate their answers. Using the boxes on the left, they indicate whether the qualities of the chords are major, minor, diminished, or augmented; with the boxes on the right, they indicate whether the chords are in root position, first inversion, or second inversion. At the bottom of the screen are four additional touch-sensitive boxes which the students can use to control the synthesizer. With the three boxes on the left, the students can have the notes of the chords played arpeggiated, simultaneous, or both arpeggiated and then simultaneous. With the box marked "PLAY AGAIN" the students can make the computer repeat the chords. In the middle of the display is a staff on which the chords are notated after the students get them right. In Figure 1 the student has listened to a chord and has pressed the boxes marked "DIMINISHED" and "FIRST." The computer has indicated that the answer is correct by notating the chord which was an E-sharp diminished chord in first inversion.

As described by the name GUIDO, which means Graded Units for Interactive Dictation Operations, there is a series of chord-quality units which the students go through during their freshman ear-training course. Table 1 shows how the chord-quality curriculum consists of twenty-two units which progress from major and minor triads in root position through all triads in all inversions. The sequencing of the students through these twenty-two units is done with a competency-based approach. The students begin in Unit 1, and they work in that unit until they can correctly answer nine out of ten consecutive chord-qualities. When they meet this 90% competency for Unit 1, they are congratulated and sent on into Unit 2. The same 90% competency is required in all twenty-two units. The students always have the option of going back to review units which they have already completed.

PROCEDURES

During the 1977-78 academic year, eighteen freshman music majors worked through the twenty-two chord-quality units in partial fulfillment of the requirements for their freshman ear-training course. An achievement test was periodically administered in order to assess the amount of learning which was taking place, and all of the responses made by students during the program were saved for subsequent analysis. The achievement test consisted of two parts. The first part tested the students' abilities to identify triads in close position, and the second part tested their abilities to identify triads in open position. Each section consisted of twenty-seven questions, with each of nine chord qualities asked three times. The nine chord qualities were M^5_3, M^6, M^6_4, m^5_3, m^6, m^6_4, d^5_3, d^6, and A.

The achievement test was administered three times during the year: first, at the beginning of the first semester before any training took place; second, at the end of the first semester after close position chords had been learned but before open position chords were introduced; and third, at the end of the second semester when all training had been completed. The test was given to all eighteen students as a group in a classroom. A piano was used to play the chords two times each in both simultaneous and arpeggiated forms. PLATO was not used in administering the achievement tests. Table 2 shows the results of the achievement tests.

RESULTS

Scores on the test administered before training were quite low, with an average score of 39% on chords in close position and 32% on chords in open position. Scores on the same test given at the end of the first semester were higher, with an average score of 57% on chords in close position and 47% on chords in open position. A correlated t-test comparison of scores on the first two tests showed a significant learning gain not only on the basis of chords in close position which were covered during the first semester by the GUIDO program, but also on the basis of chords in open position. Scores on the third test, administered at the end of the second semester, were 78% on chords in close position and 72% on chords in open position. Correlated t-test comparisons of the scores on the second and third tests showed that not only did a significant increase occur on the basis of chords in open position, but also on the basis of chords in close position.

There were two significant increases in the students' abilities to hear chords in close position. Not only did their scores increase from 39% to 57% during the first semester while chords in close position were being learned, but they also increased again by a significant amount from 57% to 78% when chords in open position were being studied. Likewise, there were two significant increases in the students' abilities to hear chords in open position. Not only did scores increase from 47% to 72% when chords in open position were being studied, but they had also increased from 32% to 47% when chords in close position were being studied. Significant increases were expected to occur on the basis of close chords when close chords were being studied, and on the basis of open chords while open chords were being studied. The additional significant gains in the students' abilities to recognize chords in close position while they were studying chords in open position, and to recognize chords in open position while they were studying chords in close position, were not expected. The subsequent gains suggest that there might be an important transfer mechanism operating in the perception of chord quality. It is interesting to note that at the end of the first year the students' scores on tests of chords in close position and chords in open position were about the same, being 78% and 72% respectively.

In order to determine the overall pattern of student responses to chord quality questions, cross tabulations were made for the student responses given on the third achievement test. In these cross tabulations can be seen the overall pattern of student responses at the end of all training in chord-quality recognition. Table 3 shows a cross tabulation for chords in close position. Table 4 shows a similar cross tabulation for chords in open position. By studying these cross tabulations, five important principles of chord-quality confusion can be discerned.

Principle 1: Response clustering. It can be immediately seen that there are three main squares on the matrices in which student responses are found. These show that there is very little confusion of chords by their qualities; rather, almost all of the student errors can be explained on the basis of confusions of inversions. There is one important exception to this rule which led to the identification of principle 2.

Principle 2: Augmented/diminished clustering. The three squares shown in Tables 3 and 4 are not all homogeneous in terms of chord quality. The first square at the top of the tables shows confusions of major chords; the second square in the middle shows confusions of minor chords; but the third square at the bottom shows confusions of diminished chords and augmented chords. When the augmented chord was missed it was always confused with the diminished chord; it was never confused with major or minor chords. Similarly, when the diminished chord was missed it was almost always confused with augmented chords. The augmented chord was correctly answered 93% of the time, whereas the diminished chord was correctly answered only 21% of the time in root position and 62% of the time in first inversion showing that this confusion pattern occurred more for the diminished chord than for the augmented chord.

Principle 3: The effect of expectations upon the perception of the diminished chord in root position. The diminished chord in root position has extremely low scores of 55% correct in close position and only 21% correct in open position. The most frequent wrong response is the diminished chord in first inversion. This shows the effect of expectations on student perception, because the diminished chord in root position infrequently occurs in the literature. Students do not hear it very often, and when they do hear it they confuse it with its more popular first inversion.

Principle 4: Major $\frac{5}{3}$ is not the easiest chord to hear. It has been generally believed that the major chord in root position is the easiest for students to identify. The data obtained in this study show that this is not true. In both close and open positions, the easiest chord to identify is the minor chord in root position, which had a score of 95% in both categories. The next most easy chord to identify was the augmented chord, and the third most easy was the major chord in second inversion. Table 5 shows how the major chord in root position was the fourth easiest to hear in open position, and only the sixth easiest to hear in close position.

Principle 5: m^6 is the most difficult chord to hear. As can be seen in Table 5, the most difficult chords to hear are the minor chord in first inversion and the diminished chord in root position. The effect of expectation explained above in principle 3 accounts for the difficulty in hearing the diminished chord in root position. Table 4 shows how in open position all but 3% of the errors in hearing the minor chord in first inversion are due to confusions of inversion. However, Table 3 shows that in close position the minor chord in first inversion is confused with diminished and augmented chords more than one-third of the time.

In the author's previous study of perceptual patterns in harmonic dictation exercises (Hofstetter, 1978), a high correlation was found between the number of times each chord was asked during training and the percentage of times each chord was correctly answered. Table 6 shows how many times each chord quality was asked during the two semesters of training on the GUIDO system. A product moment correlation was made between the number of times each chord was asked and the average score given for that chord on the final achievement test. The value of this coefficient was .1, and Fischer's t ratio yielded a t of .4, not significant at the .05 level, showing that there is no significant relationship between the number of times chord qualities were asked and the percentage scores obtained in the test. There is an important difference between this chord-quality program and the one previously reported for harmonies, because the harmony program was not a competency-based program, whereas the chord-quality program is. The lack of a significant relation between achievement scores and the number of times chords are asked in this study may be a result of the competency-based delivery system which insures that each chord is asked according to the difficulty which students have with it.

DISCUSSION

The computer-based research techniques employed in this study have enabled us to take a close look at student learning in a series of twenty-two chord-quality dictation units. First, it has been shown that a significant amount of transfer occurs between the study of chords in open and close position. After they study chords in open position, students score significantly higher on chords in close position than they do after they study chords in close position. This means that instructors need not demand a high level of mastery while teaching chords in close position, because the subsequent study of chords in open position will increase the students' abilities to hear chords in close position.

Second, study of cross tabulations of correct answers with student responses has revealed three response clusters which show how most confusions of major and minor chords occur on the basis of inversions, and more importantly, how augmented and diminished chords are almost exclusively confused with each other. On the basis of student response data it appears that there are three classes of chords: major, minor, and augmented/diminished.

Third, evidence of the role of expectation in student perception is seen in that when the root position diminished chord is played, the students almost always answer the more common first inversion form of that chord. Indeed since the root position form is so seldom found, teaching it in ear-training courses may be an esoteric exercise anyway.

Fourth, a belief which musicians have held for many years is called into question, namely, the ease of identification of the major chord in root position, which has been shown to be the sixth most difficult chord to hear in close position, and the fourth most difficult chord to hear in open position.

Fifth, an anomaly has been uncovered with respect to the most difficult chord to hear, namely, the minor chord in first inversion. In open position it is confused mainly with other positions of the minor chord, but in close position it is confused with augmented and diminished chords.

Table 1

Chord Quality Dictation Units in the GUIDO System. X's in the table indicate the content of the dictation units.

Unit	Chord Quality				Position			Structure	
Number	Major	Minor	Diminished	Augmented	Root	Ist Inversion	2nd Inversion	Close	Open
1	X	X			X			X	
2	X			X	X			X	
3	X	X	X		X			X	
4		X	X	X	X			X	
5	X		X	X	X			X	
6	X	X	X	X	X			X	
7	X	X	X	X		X		X	
8	X	X	X	X	X	X		X	
9	X	X	X	X			X	X	
10	X	X	X	X		X	X	X	
11	X	X	X	X	X	X	X	X	
12	X	X			X				X
13	X			X	X				X
14	X	X	X		X				X
15		X	X	X	X				X
16	X		X	X	X				X
17	X	X	X	X	X				X
18	X	X	X	X		X			X
19	X	X	X	X	X	X			X
20	X	X	X	X			X		X
21	X	X	X	X		X	X		X
22	X	X	X	X	X	X	X		X

Table 2

Comparison of Achievement Tests of the Abilities of Eighteen Freshman Music Majors to Recognize Qualities and Inversions of Chords in Close Position and in Open Position Before the Beginning of Training (Test I), After Training in Close Position and Before Training in Open Position (Test II), and at the Completion of all Training (Test III).

Experimental Comparisons	Subtest Identification	Mean	S.D.	t (df = 17)	p
Comparison of First Test to Second Test (N = 18)	Close I	39	29.3	7.4	p<.05
	Close II	57	21.3		
	Open I	32	26.4	6.6	N.S.
	Open II	47	18.3		
Comparison of Second Test to Third Test (N = 18)	Close II	57	21.3	8.7	p<.05
	Close III	78	16.4		
	Open II	47	18.3	11.2	p<.05
	Open III	72	19.8		

Table 3

Cross Tabulation of Student Responses and Correct Answers for the Test of Chord Qualities in Close Position at the End of Training. Numbers in the matrix indicate the percentage of times the student responses were given.

-Stimuli-

	M^5_3	M^6	M^6_4	m^5_3	m^6	m^6_4	d^5_3	d^6	A
M^5_3	79	3							
M^6	11	92	7						
M^6_4	10	5	93			8			
m^5_3				95	22	10	4		
m^6					34	4			
m^6_4				5	11	78			
d^5_3							55	7	
d^6					20		31	81	6
A					13		10	12	94

Table 4

Cross Tabulation of Student Responses and Correct Answers for the Test of Chord Qualities in Open Position at the end of Training. Numbers in the matrix indicate the percentage of times the student responses were given.

-Stimuli-

	M_3^5	M^6	M_4^6	m_3^5	m^6	m_4^6	d_3^5	d^6	A
M_3^5	89	4	4						
M^6	8	82	7		3				
M_4^6	3	14	89						
m_3^5				95	22	19			
m^6					45	7			
m_4^6					30	74			
d_3^5							21	19	4
d^6							59	62	3
A				5			20	19	93

Table 5

Rank-Order Listing of Chords in Close and Open Positions According to the Percentages of the Times Students Answered Them Correctly on the Test Given at the End of Training.

Rank	Close Position		Open Position	
	Chord	Percent Correct	Chord	Percent Correct
1	m_3^5	95	m_3^5	95
2	A	94	A	93
3	M_4^6	93	M_4^6	89
4	M^6	92	M_3^5	89
5	d^6	81	M^6	82
6	M_3^5	79	m_4^6	74
7	m_4^6	78	d^6	62
8	d_3^5	55	m^6	45
9	m^6	34	d_3^5	21

Table 6

Product Moment Correlation Between the Number of Times Chords Were Asked During Training and the Average Scores on the Third Achievement Test.

Chord Quality	Number of Times Asked During Training	Average Score on Third Test
M_3^5	2240	84
M^6	1594	87
M_4^6	634	91
m_3^5	2528	95
m^6	1442	39
m_4^6	644	76
d_3^5	2608	38
d^6	1440	72
A	4352	93

Pearson Correlation Coefficient = .1

Fischer's t = .4

$p > .05$

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"SETS"

A PROGRAM FOR SET-THEORETIC MUSIC ANALYSIS

J. Timothy Kolosick/University of Wisconsin-Madison

ABSTRACT: "SETS" is a computer program devised to facilitate numeric manipulations of set-theoretic music analysis. Given from 3 to 9 pitch classes in any order, the computer will display the prime form in addition to other characteristics of the set, based on the analytical principles developed by Allen Forte of Yale University. The program was developed on and for the Apple II Computer.

The program,"SETS," manipulates unordered pitch classes sets in order to derive their prime forms based on the theoretical principles of Allen Forte of Yale University. Dr. Forte has developed an analytical system whereby any combination of 3 to 9 notes can be reduced, for labeling purposes, to one of 208 sets of notes or prime forms. To arrive at its prime form, a combination of pitches in a given musical setting is transposed or inverted or both. For instance, the tetrachords A-G-F-E and F-E-D-C are respectively transposed and inverted equilalents of the prime form C-D flat-E flat-F with respect to interval content (see Figure 0). This set appears as pitch class set "4-11" on Dr. Forte's list of prime forms. This system gives us a concise set of labels and relationships whereby comparisons can be made in atonal structures. In his book, The Structure of Atonal Music, Dr. Forte discusses these concepts and the implications of set theory as applied to music analysis. The algorithm used in "SETS" was derived from an investigation of this book, though it is not clearly taken from any specific discussion of the derivation of prime forms.

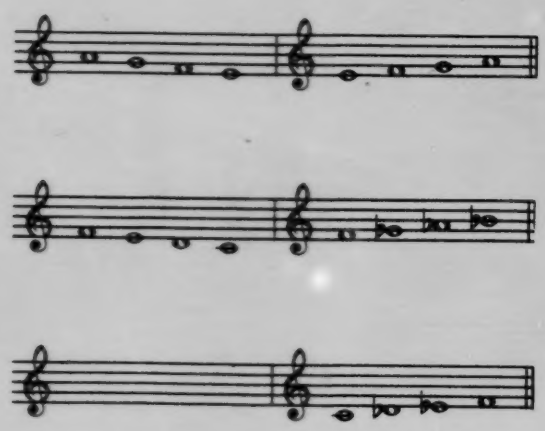

Figure 0

Once the concepts and principles of Set-Theoretic Music Analysis are understood, its application begins with a long, involved series of arithmetic manipulations. These manipulations are necessary in order to recognize and categorize a given composition's pitch content and may take weeks or even months before the actual analysis of the piece can proceed. The computer is well suited to these tasks and if employed can perform them faster and with greater accuracy than humanly possible. It also enables us to process and compare more sets within a work and explore varied combinations of tones to reveal new relationships. With the increased availability of the micro-computer, the music professor and teacher have the opportunity to enter into such computer-assisted analysis without needing expensive equipment or costly terminal time at a large

computer center. "SETS" was written on and for the Apple II Computer in the language, "APPLESOFT," a form of BASIC and can be stored on a convenient diskette or cassette tape for use.

Pitches are entered into an array as numbers or letters based on the code illustrated in Figure 1.

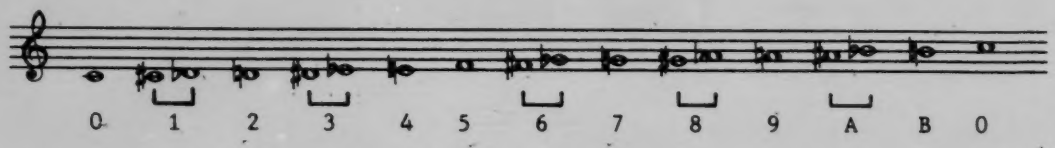

Figure 1

Therefore the set in Figure 2, from Stravinsky's Rite of Spring, is entered as [8,4,2,9] if read from the top downward.

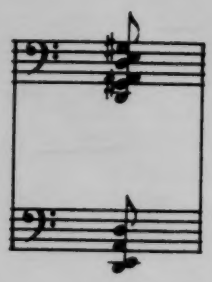

Figure 2

Any order of pitches can be used which facilitates entering them directly from the score. This array and additional "work space" are set aside in the computer as shown in Figure 3.

Should a pitch be entered twice by mistake, the diagnostic:

PITCH ENTERED PREVIOUSLY.
ENTER NEW PITCH CLASS.

appears and the second identical integer is refused. In order to inform the computer that all pitch classes are now in the array, the letter "E" for END is entered. The computer then ignores this letter as a possible pitch class and begins the manipulations.

The pitch classes were counted as they were entered into Array A. If the set contains less than 3 or more than 9 pitches, the computer will advance to the end of the program and print:

SETS WITH LESS THAN 3 OR MORE THAN 9 MEMBERS DO NOT APPEAR IN A. FORTE'S LIST OF PRIME FORMS.

The pitches entered are put into ascending order, i.e. [2,4,8,9] for the set in Figure 2, and a circular permutation, stored in Array A, shows the possible sequential orderings of the pitches (see Figure 4). The inversion is derived, put into ascending order [3,4,8,10], and is permutated in the same manner as the original set form (Figure 4, Array A:Below the line).

The computer's next task is to

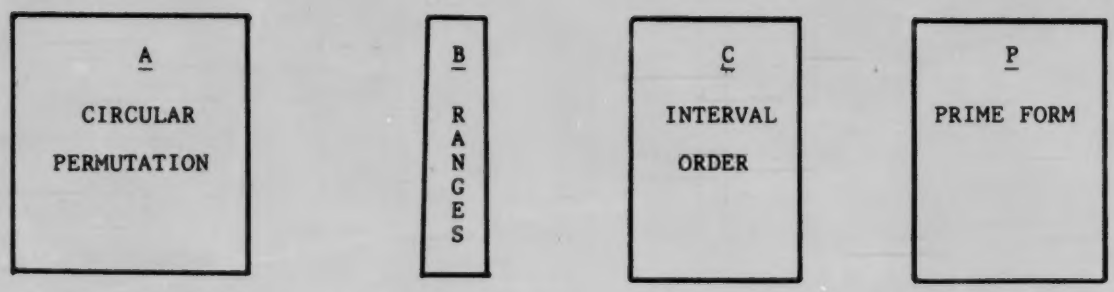

Figure 3

2	4	8	9
9	2	4	8
8	9	2	4
4	8	9	2
3	4	8	10
10	3	4	8
8	10	3	4
4	8	10	3

7
11
8
10
7
10
8
11

2	4	1	
11	11	11	
11	11	11	
11	11	11	
1	4	2	***
11	11	11	
11	11	11	
11	11	11	

I [0 1 5 7]

Figure 4

find the "range" of each ordering, that is, the interval between the first and last pitch classes and to store this information in a corresponding row location in Array B (Figure 4). The ranges are then compared to find the smallest. In Figure 4, that range is seven (7) half-steps or a perfect fifth and the 2 orderings with that range are the original pitch class set [2,4,8,9] and its inversion[3,4,8,10] Whereas these have the shortest range, they are the only 2 candidates for the proper ordering of the prime form.

In order to select the prime ordering, the computer calculates the intervals between adjacent members of the 2 remaining forms of the set, storing this information in Array C (Figure 4). Because it is necessary to keep a one-to-one relationship between the row location of each ordering in Array A and its interval order in Array C, the corresponding locations of forms which have a range larger than 7 are filled with 11's. Since the computer will be looking for the smallest intervals listed in Array C, it will "ignore" all rows filled with 11's. (Any other large number could have been used.) Array C in Figure 4 shows the intervals as they would appear after this process is finished. The computer then compares the first intervals and finds the number corresponding to the form [3,4,8,10] to be the smallest and thereupon changes all the intervals of the form [2,4,8,9] to 11's. Therefore our manipulations are complete and we have found the prime form, that is, the ordering within the circular permutation which has 1) the smallest range, and 2) the smallest interval order. In this particular case the final ordering is the inversion of the original set entered.

It is possible to have more than one form left in the array which have the same range and in addition, an identical interval order (Figure 5). The remaining form or forms are counted in respect to their location among the orderings of the original set or those of the inversion. As a result of this count, the computer "knows" whether the original set entered is a transposition or inversion of the prime form or both. When both, it indicates that for the set in question, the inverted set form is a transposition of itself.

The computer then prints the final results of its computations, the printout for Figure 4 being that shown in Figure 6. The interval order of both

0	3	5	7	8	10
10	0	3	5	7	8
8	10	0	3	5	7
7	8	10	0	3	5
5	7	8	10	0	3
3	5	7	8	10	0
0	2	4	5	7	9
9	0	2	4	5	7
7	9	0	2	4	5
5	7	9	0	2	4
4	5	7	9	0	2
2	4	5	7	9	0

10
10
11
10
10
9
9
10
10
11
10
10

11	11	11	11	11	
11	11	11	11	11	
11	11	11	11	11	
11	11	11	11	11	
11	11	11	11	11	
2	2	1	2	2	***
2	2	1	2	2	***
11	11	11	11	11	
11	11	11	11	11	
11	11	11	11	11	
11	11	11	11	11	
11	11	11	11	11	

TI [0 2 4 5 7 9]

Figure 5

```
ORIGINAL PITCH CLASS SET:
2,4,8,9

IS AN INVERSION

OF THE PRIME FORM:
0,1,5,7

INTERVAL ORDER OF THE ORIGINAL PCS:

2   4   8   9   2
 ( ) ( ) ( ) ( )
  2   4   1   5

INTERVAL ORDER OF THE PRIME FORM:

0   1   5   7   0
 ( ) ( ) ( ) ( )
  1   4   2   5

SET NAME(FORTE):          INTERVAL VECTOR:
4-16                              110121

DO YOU WISH TO ENTER ANOTHER SET?
```

Figure 6

the original set and prime form allows us to see the intervals between adjacent set members at a glance and calculate further intervallic relationships more easily. The names of all prime forms are stored in a subroutine for comparison with the derived prime form. When the identical prime form is located, the information stored within its line is printed, including the set name, its interval vector (tabulation of the total interval content), and, in the case of 6-member sets, its complement (set name of the 6 notes not in the original pitch class set). The print-out for Figure 5 is shown in Figure 7.

The user is then asked whether or not he/she wishes to enter a new set of notes to derive its prime form. If so, the program is repeated from the input of pitch classes and if not, the user may elect to request to see another form of the previous set. In the second case the form desired (transposition or inversion) is requested by the computer followed by the transposition interval. The computer then inverts and/or transposes the prime form or the original pitch class set and prints out the derived set form. This task will be performed as often as the user wishes and upon finishing and electing to enter a new set, the program begins again.

```
ORIGINAL PITCH CLASS SET:
0,3,5,7,8,10

IS A TRANSPOSITION OR INVERSION

OF THE PRIME FORM:
0,2,4,5,7,9

INTERVAL ORDER OF THE ORIGINAL PCS:

0   3   5   7   8   10   0
 ( ) ( ) ( ) ( ) ( )  ( )
  3   2   2   1   2    2

INTERVAL ORDER OF THE PRIME FORM:

0   2   4   5   7   9   0
 ( ) ( ) ( ) ( ) ( ) ( )
  2   2   1   2   2   3

SET NAME:                 INTERVAL VECTOR:
6-32(12)                          143250

DO YOU WISH TO ENTER ANOTHER SET?
```

Figure 7

The total implications and applications of set-theory analysis are yet to be fully realized. It is hoped that this time-saving program will help generate more interest in the set-theoretic approach and that other programs like "SETS" will continue to explore further areas of application to expand its use as an analytical tool.

TRIPLE P : A Comprehensive Computer-based Program in Pitch Pattern Perception

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ABSTRACT

TRIPLE P is a computer-based instructional program intended to provide students with a comprehensive set of exercises leading to accurate and rapid perception of pitch patterns of various lengths. The program is being designed to provide us with information about how students perceive such patterns, which in turn will help us better to understand how to provide such training.

The program design includes an instructor program to enable teachers to choose instructional sequences, a student program which presents the instruction, and a data collection program. The basis for the program is a twofold learning approach. One track presents pitch patterns in major and minor scale contexts, while the second focuses on intervals. The tonal approach appears to be the more pedagogically reliable and efficient, but the intervallic approach has also to be learned for non-functional or quasi-functional contexts, as well as a backup system for tonal contexts.

The first phase of the program has been implemented on the PLATO system, and a short pilot test program has just been completed. Ultimately, we hope to be able to develop this and other related programs on a stand-alone microcomputer system.

INTRODUCTION

TRIPLE P is a computer-based instructional program intended to provide students with a comprehensive set of exercises leading to accurate and rapid perception of pitch patterns. The genesis of the program was our desire to learn more about how students perceive pitch and interval patterns of various lengths and particularly how we might better provide training in the perception of these patterns by studying carefully the performance of individual students. Additionally, we are interested in providing the instructor with control over the choice, organization, and presentation of the materials so that students from many classes and at all levels of aural training might be accomodated. The program is being developed by the author and a colleague, Dr. Allen Winold, with design assistance from the Special Projects Development Office of the University's Audio Visual Center, PLATO programming assistance by one of our undergraduate students, and financial support for the programming by the University's Learning Resources Office. At present, TRIPLE P is being implemented on the PLATO system. However, our plans are to adapt it to a suitable stand-alone microcomputer system as soon as possible.

DESIGN

The program design includes three components: an instructor program to allow individual teachers to choose instructional sequences; a student or learner program which presents the instructional sequences; and a data analysis program which collects data on student performances. The basis for the content of the program is a twofold learning approach to the apprehension of pitch patterns, which we have designated tonal and intervallic. The necessity for the two tracks has been estabished or strongly implied by several studies, among them, Davies and Jennings (1977), Williams (1978), and Balzano (1979). The tonal approach may be thought of as relating stimulus pitches to a grid or network of relationships stored in memory over a period of time as a result of a listener's experience with tonal compositions. The interval approach, on the other hand, amounts to measuring the distance between successive stimulus pitches by means of an internal "ruler." The tonal approach seems by far to be more reliable, efficient, and

easy to learn, but the interval approach also needs to be learned for non-functional or quasi-functional music, and as a "back-up" system for tonal contexts.

The overall content of the program in terms of materials employed and options for creating instructional sequences is shown in Figures 1-3. Figure 1 shows the response modes and performance options common to both the tonal and interval tracks. Figures 2a and 2b show the basic instructor options available in each of the two tracks in the learner programs. Figure 3 shows the data collection options. The figures are organized to show the order of choices to be made by an instructor in choosing a learning sequence. Within any one level, boxes unconnected by lines represent mutually exclusive choices.

Looking at Figure 1 in more detail, each of the response mode options may be drawn on the PLATO touch panel to enable entry of a response by touching the appropriate point on the screen. The performance options allow the instructor to adjust the complexity of the drill materials to the skill of the student. The length of the stimulus pitches will be adjustable, as will the time for responding. Also, in the tonal approach a brief I-V_7-I cadence may be elected to be played before each pattern or before the first pattern in each different key for the purpose of establishing tonality. The presentation of pitches in the present stage of development is in equal durations, but once the program is fully operational, we will experiment with simple rhythm patterns.

The tonal and interval approaches shown in Figures 2a and 2b may each be thought of essentially as a pair of program loops, with the outer, slower moving loop consisting of the pitch and interval source materials (shown on the upper level of options in each figure), and with the inner, faster moving loop consisting essentially of constraints on the way each pattern is presented (shown on the lower level of options in each figure). In the tonal approach, the pitch class set options embrace those sets common to most triadic tonal compositions. Instances of chromaticism may be controlled in terms of the chromatic pitches allowable and how they are approached and left. For the sake of completeness, we have also included an option to select other pitch class sets that are not truly tonal in structure (the octatonic, wholetone, and chromatic scale sets) but which often appear in tonal contexts. In the interval approach our outer loop options are much more arbitrarily conceived due to lack of published research to guide our planning. For example, the instructor may elect to begin with sets of smaller intervals, e.g. the set (P1, m2, M2), then gradually increase the span of the intervals within each selected set. Alternatively, the instructor may prefer to organize materials in terms of sets of intervals increasing in difficulty of discrimination, which we have based on textbooks by Benward, Clough, et al, and on published research by Killam, Lorton, and Schubert (1975) and by Thostenson (1978), among others. Another option allows selection and organization of single intervals according to the instructor's own plan. Finally, we have included still another option enabling the instructor to select intervals in terms of their class relationships (i.e., m2/M7, M2/m7,. . ., +4/o5).

Whereas the selection of sets of pitches or intervals involves but one of the listed options, the pattern options level involves numerous choices in each learning track. In the tonal approach, after choosing the number of notes to be presented (which may be as many as twelve, including repetitions), the instructor will be able to control how each pattern is to be generated in terms of the first, last, and/or intervening scale degrees, the internal interval structure, the direction of the stimulus pitches, the rate at which the tonic changes from pattern to pattern (e.g. change every pattern, change at random), the order of tonic change (e.g. according to the circle of fifths, at random), the overall range (in scale degrees), and the tessitura (e.g. women's vocal, men's vocal). For all but range and tessitura, default options will be available. In the interval approach, after the instructor selects the number of notes, the remaining options are essentially the same as in the interval approach, except that range options provide for an increase from a minimum of four semitones between highest and lowest pitches to the total range possible in the program (four octaves, from C2-C6).

A most important component of this comprehensive program is data collection. Figure 3 shows two basic options for data collection: the complete record of stimulus patterns and responses made by the student, or partial record options shown on the right portion of the figure. By way of explanation of the term modulation as used in the figure (see the lower right scale degree error options), we distinguish between errors in absolute pitch (no modulation) and errors in which the student has entered the wrong pitches but with correct interval relationships (modulation). An instance of the latter is the response C E A G F to the stimulus C E B A G (all in one octave). For our pilot study with a limited number of students (described below) we have elected the

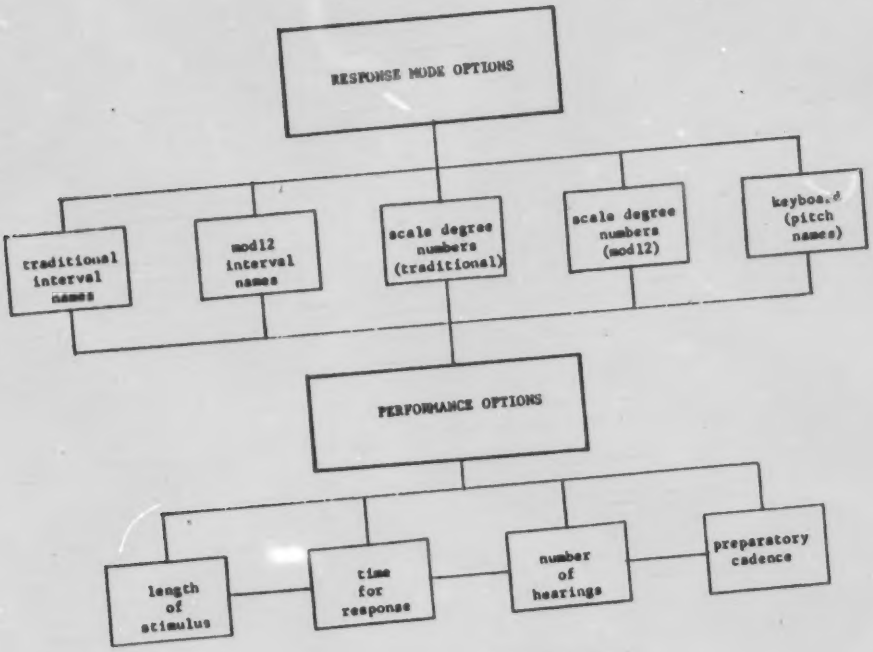

Figure 1 Initial Options for Tonal Approach and Interval Approach

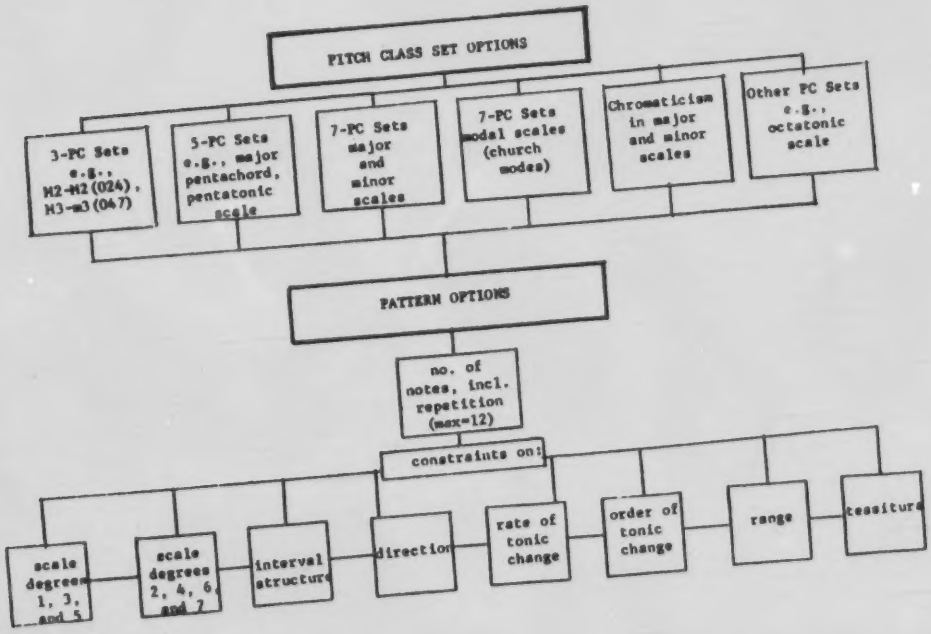

Figure 2a Tonal Approach Options

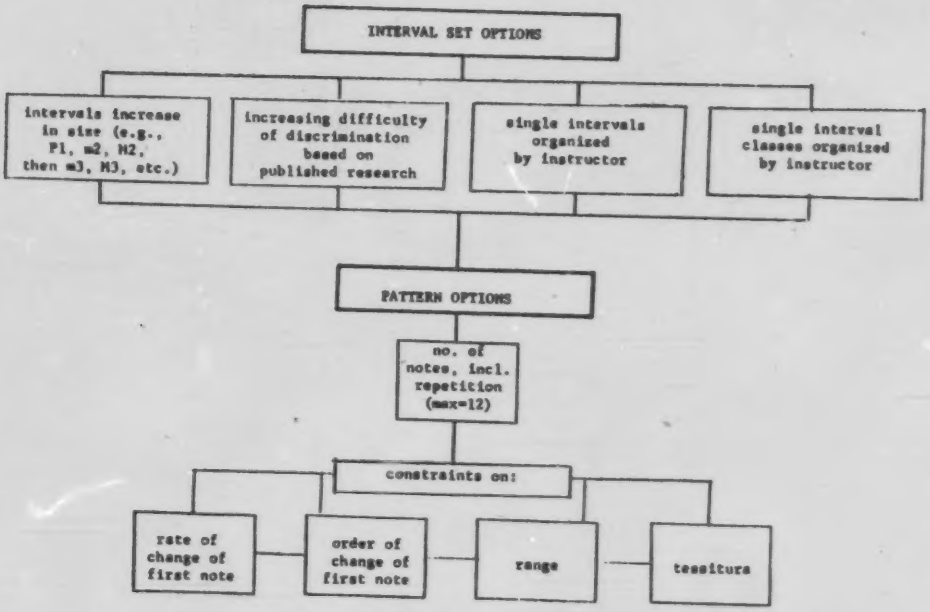

Figure 2b Interval Approach Options

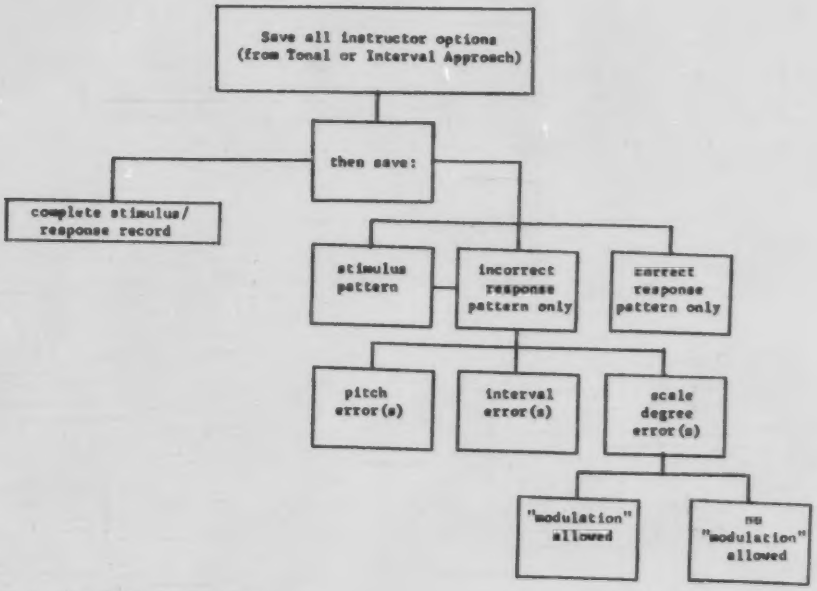

Figure 3 Data Collection Options

complete record generation option. However, due to limits on data storage on the PLATO system, we will likely use much more limited data collection when the program is fully operational. Once we begin gaining experience with data collection for this program, we will determine appropriate statistical measures for analyzing the data.

CONCLUSION

The TRIPLE P program is an attempt to construct a comprehensive set of lessons leading to increased aural acuity, that takes advantage of the power of the computer to generate drill materials according to generalized algorithms, that is modularly designed so that programming may be efficient and subsequent modifications feasible, that will provide flexibility in instructor options for designing learning sequences, and that will provide us with data from which we can determine better how students learn to perceive and organize pitch patterns. While we are aware of the difficulties inherent in constructing learning hierarchies for other than strictly intellectual skills (Okey, 1973), nevertheless we are hopeful that learner performance in our program will provide us with information enabling us at worst to assess the appropriateness of some of our present, largely intuited aural training procedures, and at best to establish more effective pedagogical strategies for aural training.

PILOT STUDY

During January, 1980, we completed implementation of the first phase of TRIPLE P. To test the implementation thoroughly, we ran a brief pilot study using a small group of freshman-level students. The PLATO display seen by the students is shown in Figure 4.

All patterns were of three pitches, with identification by scale degree using the numbers at the top of the display. A number with a line below it indicates the octave below the given tonic octave, while a line above a number indicates the second octave. Each tonic is set by a short cadence. This is followed by a pattern within one of two ranges, the first a seventh, $\underline{7} - 6$, the second a tenth, $\underline{7} - \overline{2}$; the first range is shown in the figure. Cadences and patterns can be reheard by touching the appropriate boxes on the display. To enter a response, the student touches ENTER. To change a response, EDIT is touched and the response pattern is reentered. Presently, the keyboard may be "played" by touching its keys, but it is not integrated into the response options as it will be eventually.

For the pilot study, all patterns are automatically generated as follows. Within the first range, the first pattern type consists entirely of scale degrees 1, 3, or 5, with no immediate repetition of pitches. The student must respond correctly to three patterns of this type before going on to another key. Before going on to another pattern type, four keys are employed randomly, with no immediate repetition. Within the four keys, two modes (major and harmonic minor) are employed, with major first. Thus, within the first pattern type, twelve patterns must be correctly identified. The second pattern type begins and ends on 1, 3, or 5, but the second pitch is 2, 4, 6, or 7. The third pattern type begins with 1, 3, or 5, but is then followed by 2, 4, 6, or 7 for each of the second and third pitches, again with no immediate pitch repetitions. For the second and third pattern types, the same constraints on responses, keys, and modes are employed as with the first type. When all criteria for the first range are met, patterns are then generated in the second range as they are in the first. Thus, overall, the student receives a minimum of 72 patterns (3 patterns x 3 pattern types x 4 keys x 2 ranges).

PROBLEMS IN THE PILOT STUDY

As we should have expected because of Murphy's Law (everything that can go wrong will), we were late in completing implementation of the first phase of the project. In large part, our problems were hardware related, e.g. our aging PLATO IV terminals were down too much of the time, and always at the wrong time, and one of our two music boxes overheats, thereby creating unexpected results in the audio source. Added to this is that we encountered some unusual interruptions of service from the University of Illinois. Due to these problems, we had difficulty in finding student volunteers who were at the right point in their study to provide the best test of the lesson. Moreover, since the test had to be placed at the beginning of the second semester in order to meet the deadline for submission of this report, most students were not yet sufficiently settled into their routine to be able to meet the short pilot study period requirements. The problem of timing, coupled with hardware problems that prevented several students from attempting the lesson, resulted in a group of six students, only one of whom was able to complete the whole lesson. Of these students, one missed so many patterns (over 100), that his data was lost because we had not planned for so many errors in our

data collection routine. The routine has now been revised to accomodate this possibility.

PRELIMINARY RESULTS

Time has not permitted a thorough analysis of the data collected. However, some general observations can be made on the basis of a cursory study of the data.

A total of 121 incorrect responses were collected for the five students. Of these, 61 were minor mode patterns. It is likely that had more students completed the lesson, the majority of the errors would have been in the minor mode since students more often than not have greater difficulty with this mode; indeed, for the one student who did complete the lesson, 32 of 48 errors (67%) were in the minor mode.

As one would expect, errors increased in direct proportion to the frequency of appearance of scale degrees 2, 4, 6, and 7 (pattern types 2 and 3). And errors increased rapidly as the intervals between pitches increased in range 2.

Within the first range, errors appear to be mainly of two types. The first involve being off by one scale degree, e.g. responding 5 4 5 for 5 3 5. The second type of error involves substituting one scale degree for another, e.g. responding 1 5 1 for 1 3 1. Within the second range, errors do not fall into neat categories of types. Here we will have to analyze the data carefully to determine patterns of error types that may characterize the responses.

SUBSEQUENT USE OF THE LESSON

Having tested the lesson for bugs undetermined in the implementation and being relatively sure now that everything is in working order (save persisting hardware problems that will eventually be corrected), we intend to add the lesson to the router of ear training lessons our students use and to continue to collect data in multiple use mode. We will shortly expand the range and the number of pitches within the individual patterns, thereby opening up a significant number of learner control options not now present in the test lesson. Additionally, we will improve our data collection and analysis procedures. Gradually, we hope to be able fully to implement the complete program and to realize our goals of not only providing suitable drill materials, but also of learning more about how to make the difficult problem of aural skills acquisition as efficient as possible.

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Figure 4 PLATO display for Pilot Study

PROJECT DISCO: A PLATO LEARNING SYSTEM IN CONSUMER ECONOMICS

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ABSTRACT

At the University of Delaware, A Distributive Information System in Consumer Economics (Project DISCO) is presently being developed. The overall objective of the project is to have students develop, retain, and apply "informed habits" associated with rational behavior in the marketplace. Basic to the consumer learning model being adopted as part of the project is the development of 15 PLATO lessons presenting basic consumer economic theory in layman's terms. The 15 lessons are to become part of the Consumer in the Marketplace Series (CMS) and are structured to enable individuals to develop competencies related to efficient consumption.

The CMS series reflects a "life adjustment education approach" to learning how to maximize satisfaction from spending one's income. By focusing upon the process of rational decision-making, individuals are guided through learning experiences which rely upon the use of appropriate sources of product information, which apply a variety of basic consumer economic concepts, and which enable the evaluation of consumer decisions in terms of benefits and consequences to individuals, society, and the environment.

The complexity of the American economic system and the marketplace demands educated consumers. However, there is ample evidence of the lack of knowledge and consumer skills among Americans at all educational and income levels to deal effectively in the marketplace. A recent study under the auspices of the Education Commission of the United States revealed that the level of consumer literacy in the United States is at a dangerously low level (Mohr, 1977). Findings in the study indicate that consumers are wasting billions of dollars by exhibiting uninformed spending patterns ranging from not being able to select the best buys in food products to the abusive use of credit. Statistics reported by the Education Commission support much of today's evidence that the uninformed consumer remains a serious problem, undermining personal attempts to maintain and/or improve the standard of living of large numbers of individuals in our society.

Results of another widely publicized study of the American family by General Mills (Yankelovich, 1975) support the contention that today's consumer needs to improve money management skills. The findings indicate that while attempting to cope within an inflationary marketplace, families may be making unwise or ineffective choices as to where to cut back. The rapidity of change in the marketplace compounds problems of the uninformed consumer. Frequent modifications of existing products and the rapid creation of new ones in large numbers adds to consumer uncertainty. Furthermore, the inability of governmental regulatory agencies to effectively monitor business practices contributes to the frustration being encountered by many

consumers. In spite of recent advances in pro-consumer legislation, consumers continue to be misled, misinformed, and duped.

Students in today's classrooms are required to make far more consumer choices than did their parents. Because of the large numbers of individuals between the ages of 18 and 34 in our society and the amount of money controlled by these individuals, marketing techniques have been geared towards today's youth. Evidence of abusive use of credit by many young consumers supports the need for a systematic approach to preparing individuals to interact intelligently in a complex marketplace. In addition, the growing number of articles, research efforts, and informational documents available attest to the need to deliver educational programs in consumer economics not only to the 18-34 age group but to individuals at a variety of stages of the life cycle including children, teenagers (age 13-17), adults, and the elderly--and to families at all income levels.

CONSUMER LEARNING SYSTEM MODEL

At the University of Delaware, A Distributive Information System in Consumer Economics (Project DISCO) is presently being developed. The overall objective of Project DISCO is to serve a variety of individuals through the delivery of consumer programs via PLATO Computing System. Basic to the consumer learning model being adopted as part of the project is the development of 15 PLATO lessons presenting basic consumer economic theory in layman's terms. The 15 lessons are to become part of the Consumer in the Marketplace Series (CMS) and are structured to permit accompanying class activities to focus upon six cognitive behaviors: knowledge, comprehension, analysis, applications, synthesis, and evaluation.

Program Content. The Consumer in the Marketplace Series (CMS) begins with the study of the consumption act in which an analysis of how decisions are made by the consumer when accumulating a variety of goods and services is conducted. The PLATO lessons then alert the consumer to a variety of information forms in the marketplace and how such mechanisms have a tendency to mold consumer behavior. The process of indexing is examined in terms of the kinds of information available to the consumer. During this lesson, the Consumer Price Index is studied in great detail. Then the process of rational decision-making is presented in terms of the costs-benefits of purchasing. A Decision-Matrix Analyses is completed as the student examines product attributes and consequences in a systematic study of consumer actions. These lessons are grouped together to formulate Phase I of the CMS series.

During Phase II, an earnings component is presented. Investment in Human Capital and Opportunity Costs are studied in terms of the changing roles of the male and female in the family units. The focus here is upon the process of accumulating earnings which are eventually used in the marketplace for a variety of purposes.

The next group of PLATO lessons reflect important aspects of the art of purchasing as major areas where considerable sums of money are spent by today's consumers are studied. The CMS series focuses upon product liability as an examination of the purchasing of consumer durables is undertaken. The area of credit is analyzed as transfer of income is studied within the framework of an inflationary economic cycle. In addition, the series includes an examination of a systems approach to providing transportation and health care--and its impact upon the life style of today's consumer. Investment portfolio activities of the consumer are studied in terms of protecting family earnings and hedging against inflationary pressures. Finally, transfer of payments is examined in terms of how government is financed and the restraints such financing has upon consumer spending patterns.

Phase IV of the CMS series examines the political and legal framework within which individuals must function in our society. Regulation is studied in relation to the role of Federal agencies in monitoring the marketplace. Consumer Rights are then examined within a legislative framework including a presentation of appropriate steps to be taken when seeking remedies in the free enterprise system.

Instructional Approach. The CMS series provides a mechanism for systematically analyzing consumer behavior in the marketplace as effective consumer skills are developed by the learner. The basis for the adoption of an analytical approach of study is that since the marketplace is constantly changing, there is no need to memorize facts about issues. However, the analytical approach adopted in the consumer learning model permits an individual the opportunity to analyze consumer behavior and corres-

ponding issues, thus enabling the student to develop an ability to apply, analyze, evaluate, and synthesize information with a conceptual framework. The PLATO lessons currently being developed guide the student through a series of experiences which analyze why individuals behave the way they do in the marketplace--and the consequences of such actions.

Accompanying the PLATO lessons are classroom activities which require students to examine problem situations; analyze alternatives and predict consequences of proposed action; and synthesize an approach which may be justified within a complex marketplace. During this process, class activities focus upon student beliefs, attitudes, and values which are all important aspects of the consumption process. Throughout the consumer program, group interaction focuses upon utilizing limited resources (both environmental and personal) and maintaining a healthy balance between conservation and consumption.

TARGET POPULATIONS OF PROJECTS

In using the PLATO Learning System at the University of Delaware, three target populations are being served. One target population which is presently being focused upon during the developmental stages of Project DISCO are students in educational institutions. The thrust in this component is to serve students in secondary and post-secondary institutions by providing a systematic program of learning activities reflecting real-life experiences. Accompanying classroom activities can be easily adapted to students who are at varying learning stages. The PLATO lessons are being developed in layman's terms which allows the study of consumer economic concepts "on a no-frills basis." At the present time, PLATO lessons in the CMS series are being developed for use by students enrolled in consumer economic offerings at the University of Delaware.

A second target group are teachers who are either in the process of having consumer education responsibilities at a variety of levels of education or those who may be in the process of preparing for careers in teaching. The third group is the adult who is not actively involved in a formal educational process. The expected development of terminals for home use will assist in reaching this group of individuals. The PLATO lessons will provide the medium for reaching a variety of individuals with different needs and characteristics. The classroom instructor may easily adapt the PLATO lessons by personalizing applications and problem-solving experiences to meet the objectives for these groups of individuals.

CONCLUDING REMARKS

Project DISCO is an attempt to use basic consumer economic theory as the basis for teaching a variety of groups in our society to become effective consumers. The breaking down of content via CAI PLATO program (e.g., pretest, program delivery, posttest) permits the opportunity to analyze individual behavior while becoming efficient consumers. The CMS series reflects a life-adjustment education approach to learning how to maximize satisfaction from spending one's income. By focusing upon the process of rational decision-making, students are guided through learning experiences which rely upon the use of appropriate sources of product information, which apply a variety of basic consumer economic concepts, and which enable the evaluation of consumer decisions in terms of benefits to the individual, society, and environment. The overall objective of Project DISCO is to have students develop, retain, and apply "informed habits" associated with rational behavior in the marketplace.

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MICROPROCESSOR APPLICATIONS IN READING INSTRUCTION, DIAGNOSTIC TESTING AND EVALUATION

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ABSTRACT

A discussion of potential microprocessor applications in the field of reading instruction, testing and evaluation.

It is an educational bromide to say that we are on the verge of a revolution in instructional technology in the 1980's. Educators have probably said the same at the beginning of every decade since Edison first reproduced the human voice.

And at the end of every decade the promise of radio, television, tape recorders, video taping devices and sundry teaching machines come up disappointingly short of predicted "revolutionary" expectations.

And perhaps it will be so in 1990 with regard to microprocessor applications in the field of reading instruction. But many of us who are working with the potential of this technology do not think this will be the case.

There are too many creative, knowledgeable and experienced reading teachers, researchers, and designers out there with a collective gleam in their eye, experimenting with Apples, Ataris, PETs, and 80s to see what can be done.

These innovative people are busy because they are aware of the vast potential microcomputers have in the field of reading for such diverse activities as: (1) testing response latency, perception testing, and testing achievement; (2) simulating fluent reading patterns at all levels of reading development; (3) teaching with branching tutorial logic; (4) presenting drill and practice sets in such a way that learners will happily attend to "game" exercise formats: (5) provide interactive instruction with voice synthesis under program control so that a reading handicapped student can learn the correspondence between phonemic(spoken) and graphemic(written) language.

Computer aided testing and instruction can do all this as an adjunct to the traditional "lecture" classroom teaching format and it can teach reading skills in an autotutorial, stand-alone basis.

But regardless of the instructional application or philosophy, CAI has the unique ability to evaluate the progress of each learner interacting with its curriculum material and recycle them as often as it is necessary to learn a concept or demonstrate the acquisition of a skill.

Thus mastery learning may finally be transformed from pedagogical shibboleth to educational reality. Then, like Mr. Masson's wines, no learner will be promoted before his time.

Up until now there have been several factors which have constrained a headlong dash by commercial developers to be first in the marketplace with micro-delivered CAI educational materials.

Number one has been cost. One estimate from Electronic Data Systems in Dallas ranges from $250,000 to $350,000 dollars for the development of a complete curriculum in reading, math and language arts, 3rd grade through 6th.

Personally I would say that $350,000 as a final dollar figure is low for a project of such ambitious magnitude.

The second factor constraining development has been the cost to schools of a versatile micro-delivery system with sufficient peripherals to do the job. At three thousand dollars plus per unit, it would be an unusual school district that could afford ten to twenty delivery systems($30,000-$60,000) and then purchase the curricula to go with them($10 dollars per student or so per year.)

But even though this figure seems

high, it is comparatively inexpensive when compared to mainframe CAI curricula(Plato) or a mini-system delivered curricula(Computer Curriculum Corporation).

Another constraint that has impinged on CAI acceptance in general has been the lack of a speech component under program control for instructional and cueing purposes.

In other words, a learner had to be able to read already in order to learn to read through CAI in the past.

This concern has now been obviated by the development of an unlimited vocabulary speech synthesis board by Votrax and the fact that MCA Phillips(Magnavox) is developing a random access recorded human speech peripheral based on laser scanned video disc technology(up to one hour of continuous and randomly accessible speech per disc).

Both of these devices may be available in the marketplace for less than $250 dollars each in quantity orders.

What this new audiotry component will do for the acceptance of CAI and CAT(Computer Aided Testing) in my opinion will be the rough equivalent of what the "talkies" did for the nascent movie industry in the early 1930's

But what will these miraculous reading and basic skills curricula for micro-delivered CAI look like? Let us look into the future.

First, each school, or perhaps district, will have at least a twenty carrel/20 unit-networked-to-a-hard-disc-for-data-management lab. Here will occur the computer aided testing and instruction. During the initial weeks of school, students will be tested at a rate of 20 or so per half hour. Existing criterion referenced reading tests can be adapted to CAT techniques and each student will be tested in areas of reading subskills to determine his/her overall reading level. A prescription will then be compiled from the test data that may include some further CAT "perceptual" testing if indicated.

One CAT technique that will help to isolate perceptual disorders is the recording of response times to tachistoscopic presentations of words or numbers(response latency). The next step would be to test for figure-ground confusion, spatial relationships, and short term auditory and visual memory if a slow response average is detected.

Another important advantage of CAT is that the interpretation of tests results will be nearly instantaneous(compared to hand scored tests) and can be hard copied(printed) for teacher/counselor/specialist use.

The results can also be keyed prescriptively to any major basal series, CAI suplemental skills sequence or completely individualized tutorial package (which would be appropriate in the case of severely handicapped individuals).

Also, after a pre-determined period of instruction, a different form of the same test materials can be administered, thereby assessing the amount of incremental advance, if any, that has taken place due to instruction.

After the testing and prescription has been completed, the instruction can begin.

Initially I'm afraid, this instructive technology will be resisted by the educational establishment as a threat to the future employment security of teachers. But in this regard I feel that given a consciousness raising(or anxiety lowering) orientation to the concept of mastery learning theory through CAI, teachers will soon come to see that microcomputer as a friend and indispensible adjunct to their efforts, not as an enemy in budget competition with salary lines.

Now what--you are asking yourself--will this micro-delivered curriculum be doing exactly, to make apostles out of such a potentially hostile multitude of reading teachers?

First and most importantly, the micro-processor will demonstrate to beginning readers, the correspondence between spoken(phonemic) and written(graphemic) language with a strategy that is not unlike the technique of neurological impress.

In other--perhaps clearer--words, everything that is desplayed on the monitor screen, word by word or even syllable by syllable, will have its auditory equivalent conveyed to the learner simultaneously.

Thus the relationship between spoken and written language will be emphasized, for all learners good, poor and even the indifferent.

Much of this technique will be accomplished through the use of graphically exaggerating print feature differences for visual discrimination training with animated graphics and various tachistroscopic presentation techniques, etc.

Another example of computer application is in the area of reading fluency training. This is a technique whereby normed eye patterns of each grade level of natural reading development can be graphically simulated in context. The learner can also control the rate of presentation to accommodate individual differences.

This fluency training technique will enhance a reader's ability to use more semantic and syntactic cues(an increase in the laterality of print apprehended) dur-

ing the reading process which in turn can increase rate and promote better comprehension.

In the area of special education with the reading handicapped, the microprocessor is capable of producing exercises for the specifically disabled learner such as directionality training, sequencing simulation, color cueing and tachistoscopic redundancy training. At present there is some experimentation in progress which includes dichotic visual and listening strategies for hemisphere confusion cases as well as work on the development of instructional strategies to help both dysphonetic and dyseidetic dyslexics.

Of course, the greatest asset of microprocessors with handicapped students is its ability to patiently repeat(and change the context of the repetition) until the learner can demonstrate mastery of the skill being taught or practiced.

Even if this takes 100 or more repetitions!

Obviously it is this area of repetition, redundancy and drill and practice that the micro's unique capability will melt teacher opposition to CAI, for there are few teachers who could go over material 100 or more times with an individual without showing impatience or frustration.

Another aspect of CAI in general that needs to be mentioned here is the concept of "learner control". The computer is a "cool" medium of instruction, i.e., it does not become emotional with students or harbor secret racial or class prejudice. The computer teaches uniformly and temperately(if it has been so programmed). And don't forget that all of the interaction and behavioral reinforcement of this "cool" medium is positive.

Thus the computer may quietly remove punishment as an instructional strategy in American schools when students are observed learning without it. This should be especially beneficial with inner city and minority students who are often disruptive in class because they equate all authority with repression and exploitation.

Also for English as a second language student, the talking computer will be an invaluable drill and practice tool which can provide immediate feedback as well as translate instructional material between English and mother tongue.

I am sure that the preceding list of micro applications in reading instruction and testing barely scratches the surface of the possible applications.

And I am sure also that as teaching practitioners in the field of reading become familiar with the capabilities of the small computer, the list of adaptations and applications will grow accordingly.

And I think we all hope that this will be the case.

INSTRUCTIONAL DESIGN CONSIDERATIONS AND TEACHING STRATEGY IMPLEMENTATION USING MICROCOMPUTERS

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ABSTRACT

The use of microcomputer technology in instruction has created considerable interest in potential users. This interest is due largely to the advantages offered by low cost, easily portable micro-systems which can support a wide range of peripherals. In addition, new technologies have increased the capabilities of micros to include the use of color graphics, animation, and music and speech synthesis in a way that has not been possible with other computer systems. In short, microcomputer technology makes available an extremely flexible and powerful teaching tool at a price that is finally cost-effective for most users.

To fully develop this newly found potential, special design considerations should be utilized in the development of instructional programs. The purpose of this paper and demonstration is to present examples which illustrate various design features which can be utilized to create effective instructional programs for use in microcomputers. This paper will explain general characteristics of instructional program design, specific design criteria and key features of teaching strategies. This explanation will be accompanied by a demonstration of these design features using actual frames on an Apple II microcomputer which illustrate how color, graphics and animation can be used to enhance an instructional program.

The availability of personal computers has generated much interest in designing instructional programs for use with them. Most of the programs developed to date have been somewhat limited in scope and employ few of the capabilities offered by microcomputer systems. Most curricula which have been developed, in fact, use a basic drill and practice format and give little concern to the branching, cueing and reinforcement features of computer assisted instruction which make it the powerful teaching tool it is. As a result, these programs often engage learners in task confusion, unstructured repetition of format and content and limited skill development. The effect on learners, therefore, is that they perceive these programs as page turning exercises or electronic workbooks. An example of task confusion would be as follows: The learner is presented with the task of distinguishing between complete and incomplete sentences:

The store closed early for the weekend. Type comp (for complete) or inc (for incomplete)

The task here is discrimination of complete or incomplete sentences, but it is confused by asking the learner to type Inc or Comp. The instructional sequence, therefore, is marred by not only a poorly designed drill and practice but also by a poorly conceived format. An improved format would simply ask the student to respond by typing a 1, for complete, or a 2 for incomplete, thus focusing attention on the discrimination task rather than on the typing task.

While this example is fairly specific, it represents a rather major design error. On a more grand scale, developers of computer based programs usually ignore the wide range of teaching strategies which exist. Tne microcomputer offers not only a choice of teaching strategies such as simulation, tutorial, and instructional gaming (these will be covered in more

detail later) but also the use of graphics, color and, more recently, animation. These design features, used creatively, can add effective possibilities to the instructional process.

Another feature of program design which is often ignored by program developers is learner control over the instructional sequence. Granted there are situations where a presentation of instruction must be absolutely linear in nature. Certain subjects and concepts require it. In most other cases, however, consideration should be given to allowing the learner as much control over the learning sequence as possible. Options should be incorporated into the instructional sequence which allow for review of previous frames, for decisions about the type, difficulty level and number of problems or exercises received; and for alternative branching routes which might lead to the accomplishment of lesson objectives in less time. In short, students should be given the opportunity to advance, review and exit lessons except where such control defeats the purpose of the lesson. The ability of learners to pace themselves provides a degree of individualization not present in purely linear programs.

This feature, as well as five (5) others relevant to the design of computer based programs, have been detailed by Caldwell and Rizza (1979), These additional features include:

1. A system should be totally individualized and offer highly adaptive and responsive learning environments.

By allowing self-pacing and individualized branching, learners are helped to select the pathway through the materials which is most appropriate for their needs.

2. Programs should be modularized and structured in coherent, hierarchical patterns.

This allows for great flexibility in program implementation in that curriculum materials specifically address each necessary skill in a defined content area in a manner that provides for development of skills not mastered or allows bypassing of skills which have already been mastered. This can reduce student frustration and increases curriculum effectiveness.

3. All skills to be mastered should be carefully stated in performance objectives.

The accuracy of a program is based on the specific definition of the objectives in terms of performance competencies. This allows for precise diagnosis of skills already mastered, remediation in skill deficiencies and exact evaluation of learner progress.

4. Progress should be measured in terms of mastery of performance objectives.

5. Strategies for diagnosis and prescription should be utilized.

The efficiency of a program is due primarily to the diagnostic inventory made of the skills of each learner. This information can then be used to place them appropriately within the curriculum and to direct learners to the instructional material most appropriate to their needs.

6. Programs should be, when possible, multi-sensory in format.

In summary general program design should incorporate various teaching strategies to add variety to an overall curriculum and to address cognitive processes at all levels of that domain of learning. Also, programs should utilize to their best advantage the features of color, graphics, and animation offered by microcomputer technology. Exciting new developments in speech and sound peripherals also exist and should be incorporated where relevant and appropriate. Also, learner control over the instructional sequence allows for individual pacing and better opportunities to achieve mastery.

SPECIFIC DESIGN CRITERIA

Programs of computer based education have been developed in a variety of designs and formats. Some utilize drills arranged in "strands" while others are built around a series of tutorial lessons. Many even incorporate all or most of the features mentioned above. Within these programs, however, exist characteristics of instructional design which heavily affect the success of the instruction. The following is a description of some of the more common characteristics of lesson design which can contribute to instructional effectiveness.

A. CRT Display Format

Many alternatives can be utilized to break the monotony of lines of text filling an entire screen:

1. Use graphics to box important sentences or paragraphs. Boxes made of lines or keyboard characters do nicely to alter the visual display of text on a monitor. Reverse highlighting and color can also be used effectively to accentuate visual displays. Microcomputers can also be linked to bit

pads which make extremely interesting displays in almost any size or shape.

Whatever is used it is crucial to interrupt continuous lines of text on a screen. If this is not done the screen often looks crowded and can cause verbal overload in many students.

2. Allow the student control over the sequence of presenting text. This can be accomplished by breaking large portions of the text into discrete units or segments which students call up in sequence by merely pressing the space bar or some other key which has been activated for this purpose. This serves two purposes: it allows the learners to read at a rate that is appropriate for them and it breaks the reading task into small segments so that the reader is not overwhelmed by page after page of text appearing on a screen.

3. Animations, graphics, cartoon characters all serve to create variety and interest in the display which appears on the monitor. Used creatively and imaginatively, these capabilities of microcomputer systems can contribute greatly to effective instructional programs.

4. Double space text material whenever possible. This will enhance the visual effect considerably.

B. Interaction

Learners should be made to make decisions about the learning sequence as often as possible. The power of computer based education resides in the ability to shape learner response through trial and reinforcement. Programs which present large segments of written text and which promote interaction in only a few frames defeat the very nature of computer based instruction.

Salient features of interaction include:

1. Cueing and Reinforcement--Incorrect responses should be followed by a cue to help shape correct responses. Otherwise the interaction becomes meaningless. As an example, consider the following sample exercise:

--- Add - ing to the word ---

Come > _____

(Here students are required to transform the word by retyping it with an -ing ending.) A correct response on the first try would warrant positive reinforcement such as, "great, super, well done, excellent." These and other reinforcing statements can be generated randomly from a list of 20 or 30 possible statements. Incorrect responses follow a pattern of shaping and cueing which hopefully lead the student to the correct answer. For example:

First incorrect response:
Come > Comeing (drop the e). The student is cued by reminding him/her of the rule under examination (drop the e).

Second incorrect response:
Come > Comeing . In this second prompt the computer system animates the e in come and it drops from the equation then the -ing moves into place.

Third incorrect response:
Come Coming. If on the third try the student still does not type the correct response, the correct answer should be given and the student should then move on to the next problem. This type of reinforcement pattern contributes to meaningfulness of the material to be learned in that it:

a. Provides specific information which helps to correct learner behavior toward achieving the desired outcome.

b. Reduces the frustration often experienced by learners in CAI programs that simply provide a "no" response to an incorrect answer. This simple "no" type of reinforcement is unsatisfactory because it provides no specific feedback which will enable the learner to discover correct responses. Instead learners are forced to guess until the correct answer is found (Caldwell, 1979).

In general, reinforcement strategies depend largely on the nature and type of learning being attempted. Reinforcement, however, can be made more meaningful if it is personalized and specific to student response sequences. (e.g. "You did well, Allen, but would you like to review prefixes before going on?")

2. Responses Modes--Like reinforcement, the method one chooses to allow student input and response depends heavily on the nature of the material being learned. Response modes most commonly include typed response, touch panel response, or light pen response. The first criteria for choosing one of these modes is whether the response mode is appropriate to the objective. A perfect illustration of this is in the example cited earlier where students are asked to discriminate between complete and incomplete sentences. In this case a typed response was inappropriate to meeting the objective. In fact, typed responses in general seem to be prone to high error rates because of the nature of typing tasks (Caldwell, 1974). Typed responses also become time-consuming especially with learners who are

unfamiliar with the keyboard. This can have the effect of distracting learners from learning the concept being presented. A related problem is that many errors in typing are judged by the computer to be incorrect responses and therefore students are routed into remedial sequences when they in fact know the concept being studied.

Similarly, if typed responses are not carefully cued, learners will often be forced into "open loops" (i.e. they try to find the correct answer by typing random responses). When this occurs learners have little idea about what is expected of them and become frustrated trying to find the response which will advance them to the next frame. This is a common error made by instructional designers and has an extremely negative effect on learners.

Some advantages can be found in the typed response, however, which are not present in forced choice response modes (Caldwell, 1974):

a. Learners seem to express more favorable attitudes toward writing and the use of verbal language.

b. Spelling skills and the ability to generate language improve.

c. Personalized feedback is made possible through entry of student input.

C. Adaptive Instruction

So far it has been pointed out that the computer offers many advantages for branching, diagnosis, remediation, and review. This flexibility can add significantly to instructional programs if it is designed and implemented carefully. Pacing, cueing and reinforcement also have been mentioned as means for enhancing interaction and meaningful learning. To that list might be added the following means of adapting computer based instruction to the learner's responses:

1. Menus--Students may choose from a variety of options within a lesson or within a program. This allows the learners flexibility to pursue their interests or to control the sequence in which topics are presented. For example, a language lesson which deals with "predicates" might allow students to access concepts which have no particular instructional sequence. The menu might appear as follows:

PREDICATES

Which would you like to study:
1. Predicate Nominative
2. Direct Object
3. Indirect Object
4. Predicate Adjective
5. Review
   a. Linking verbs
   b. Action verbs
   c. Adverbs

Choose a number or letter

2. Performance Options--Learners should be given a variety of activities and in addition a choice of content. Tutorials should be accompanied by creative drills or instructional games which reinforce skills and information and which enhance the interactive nature of the instruction. These games and drills can stimulate motivation by capitalizing on a novelty effect. Competition in the games can be against other students, the computer itself, time limits or performance criteria set by other students (e.g. "the best score on this game to date is ___ " or "The best time for this game is ___ ").

A word of caution is appropriate here, however. In an attempt to bring novelty to their programs, some designers have defeated their own goals. In one such lesson students are encouraged to save a man standing in a deep pit from a large heavy stone which is slowly rolling down a hill. This is accomplished by solving a series of math problems successfully. With each correct answer the tiny man moves up the side of the pit wall toward freedom. If the learner fails, the stone, of course, falls into the pit and squashes the poor fellow. In an observation of this sequence with several children, a number of them chose to see what would occur if the stone were allowed to fall into the pit. Much to their delight, they squashed the tiny character with the full knowledge that they were solving the math problems incorrectly. This sequence, therefore, did little for math skills but did much to reinforce the brutality and violence children see daily on television sets.

The scope of this presentation limits discussion of the many subtle variables which contribute to effective instructional design, but attempts to begin an organization of some of the features which seem to contribute to successful programs. It is hoped that it might stimulate other authors and

designers to share their rationales and experience in designing high quality programs of computer based education.

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Examination of a PLATO-based Psychology Research Laboratory for Visual Perception

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ABSTRACT

The conduct of experiments investigating perceptual and attentional processes in human subjects requires a computer system with two characteristics. First, precise timing of visual displays and human responses demands a dedicated microprocessor. Second, the quantity and complexity of the resulting data base require the facilities of a large time-sharing system. The PLATO IV system with the PLATO V microprocessor based terminal provides both of these elements. Software was developed which allowed effective communications between the terminal and the mainframe. This system proved to be an ideal tool for the study of human perceptual and attentional processes.

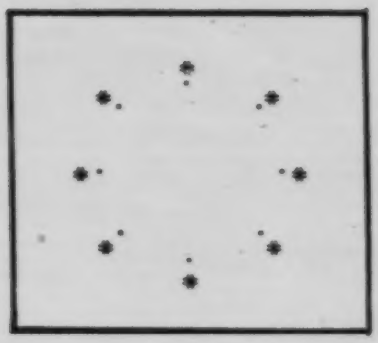


Figure 1-1 Dummy Array

Description of Paradigm

Imagine that you have just responded to a newspaper advertisement asking for paid volunteers for an experiment in perception. Upon arrival at the laboratory you are seated in front of a computer terminal and given the following task. On each of a set of trials you must memorize a small set of letters (eg. "C" and "Q") and then determine whether or not either letter is present in a briefly flashed visual array of eight letters. Figure #1 illustrates why this apparently simple task might prove difficult. First an array of 8 "masking" symbols (Fig. 1-1) is shown for 500 msec followed by the letter array (Fig 1-2). In addition to determining whether a target is present amongst the letters you are also required to determine which of the 8 dots located next to each letter is briefly extinguished (28 msec). After pressing a key to indicate whether either of the targets is present, the third array (Fig. 1-3) in the sequence is shown which asks you to indicate the location of the flickering dot.

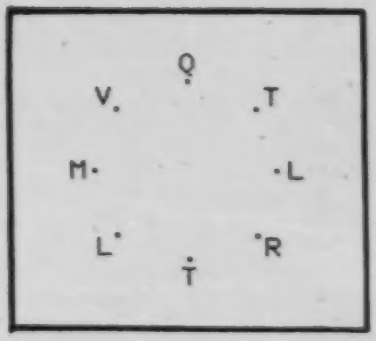
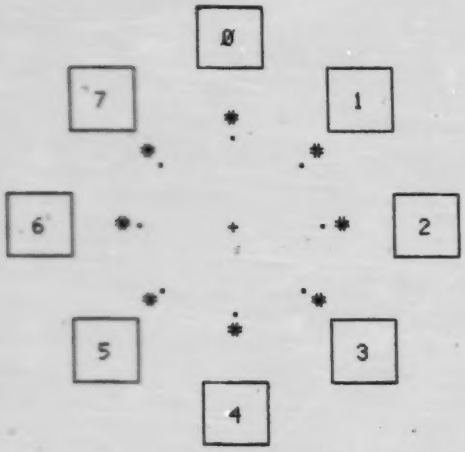


Figure 1-2 Trial Array



TYPE the number of the box to indicate the probe position.

Figure 1-3 Probe Location Array

The speed and accuracy of your target search response as well as the accuracy of your location response are recorded. After 10 hours of practice (and 3000 dividual trials!) the letter search task becomes "automatic", i.e., it is very fast and doesn't seem to depend on conscious attention to the task. The question of interest is whether such automatic behaviour can interfere with performance of a flickering light. Common experience indicates that automatic tasks such as driving a car can be done in conjunction with other mental activities such as talking daydreaming, etc., but what might careful experimentation reveal?

Experiments such as these have become commonplace in the psychological laboratory since the advent of the small digital computer. The requirements of a rapid sequence of visual displays and accurate timing of the subject's responses are well met by a computer that can be dedicated to a single laboratory function. On the other hand there are logistical considerations that would appear to call for the storage and computation facilities of a large time-sharing system. Each of a large number (30) of subjects must be able to use the system at their convenience. Over the course of 14 hours of experimentation some 330,000 bits of data must be collected, stored, and analyzed for each subject. These two goals, the speed of a dedicated microcomputer and the mass storage and computational power of a large mainframe, were achieved through the use of the PLATO IV system.

The PLATO IV System

The PLATO system contains both of the elements required to achieve the above described goals. The PLATO V microprocessor based plasma terminal (PPT)[1] has a 512x512 dot addressable graphics screen capable of writing speeds of 2000 characters per second. Each terminal contains 16K words of memory sectioned into 8K words of read-only memory (ROM) and 8K words of random access memory (RAM). The ROM contains the terminal's resident programs for screen display, user input acquisition and communications with the host mainframe. A small portion of the RAM is dedicated for terminal resident storage and loadable character sets leaving a large portion for user written assembly language programs which may be loaded from storage on the mainframe host and executed using user routines as well as callable resident routines. The terminal is connected to a large mainframe (CDC Cyber 173) host which provides excellent editing facilities as well as the high level programming language TUTOR[2].

Our task was to arrange effective communication between the terminal and the mainframe to allow us to take advantage of the unique facilities provided by each component. Figure #2 graphically represents the flow of communication between the terminal and the mainframe. A TUTOR program was written to perform the following operations. First it loaded the terminal with an assembly language program which was responsible for those events on each trial that were "time critical". These included presenting the sequence of arrays shown in Figure #1, timing the flicker duration, waiting for a key press from the subject (indicating a response), and measuring the subject's reaction time.

The main TUTOR program determined the particular characters to be shown during a given trial and passed these to the terminal (the PPT program). The PPT program then interrupted comminications with the main program, presented arrays and collected the data. It sent the data back to the TUTOR program employing communications checks to insure error free data transmission. The TUTOR program stored the data and prepared the displays for the next trial. This procedure was repeated until all trials in the session had been completed.

Fifteen individual pieces of data were stored on each trial. TUTOR programs were created to reduce these data and eventually files were transferred to a Burroughs B7700 computer for analysis with standard statistical packages.

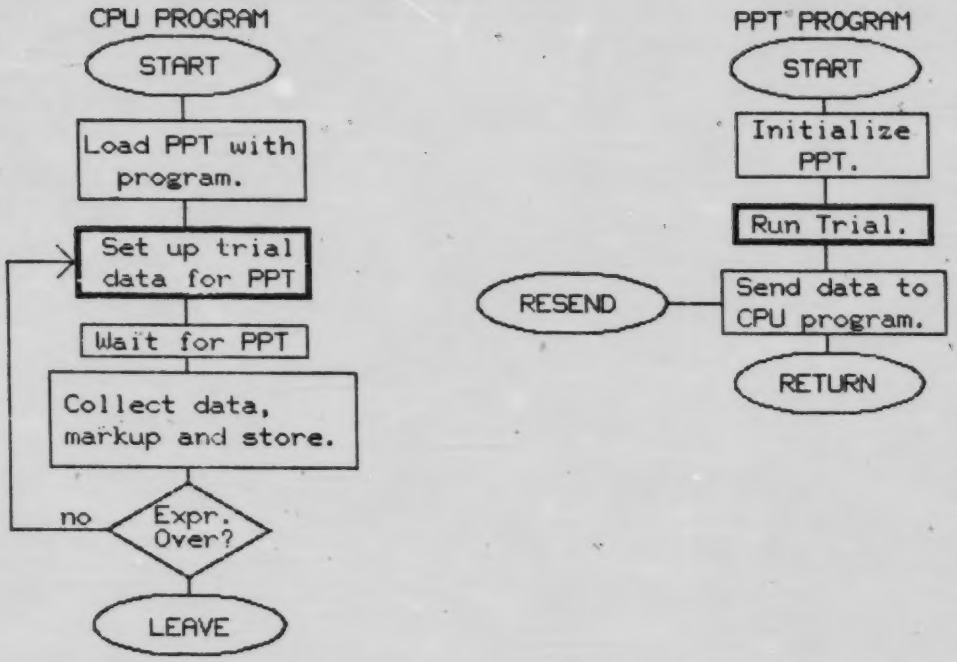


Figure #2 CPU/PPT Program Flow

Conclusions

The PLATO system proved to be an excellent solution to a problem which required both the speed of a dedicated microprocessor as well as the storage and computational power of a large time-share system. The PLATO V microprocessor based plasma terminal proved to be an ideal graphics device for presenting fast, high resolution displays required in perception experiments. The assembly language programs allowed the terminal to both receive data and send data to the mainframe providing the ability to create a large data base.

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[2] B. A. Sherwood, "The TUTOR Language", Computer-based Education Research Laboratory, University of Illinois, Urbana, Ill. 61801

GUIDELINES FOR ANALYST TRAINING

G. Thomas Judson

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ABSTRACT

As the use of computer-based training for industrial analysts increases, it becomes more obvious that material targeted for them meet minimum student-acceptance criteria.

Using the analyst's self-perception as a frame of reference, this paper suggests guidelines for the preparation of lessons intended for the professional DP analyst.

Analyst training is a subject taken seriously by most field managers and training specialists. Weinberg discussed it in The Psychology of Computer Programming[1] by addressing the learning behaviors and the learning environment of programmers and analysts. I want to briefly discuss the analyst's perception of training material in the PLATO* environment.

What kind of terminal-based material do analysts receive well? Observation yields that analysts appreciate (and that is a key word) courseware which is:

Highly interactive;
Modular;
Personal but not idiomatic;
Task oriented;
Creative.

Each of these will be discussed briefly.

*PLATO is a registered trademark of Control Data Corporation

HIGHLY INTERACTIVE

Interaction is central to any analyst's acceptance of terminal material. Specifically, the interaction should allow the student to PARTICIPATE in the presentation of the material. "-NEXT- to continue" is acceptable only when there is no other method available. Touch input holds promise in this area. For example, an analyst might be asked to touch the byte in a CM word diagram to see the area under discussion. Labels and byte boundaries appear in response to the touch.

Two aspects of interaction are demonstrated in this approach, both of which seem to appeal to analysts and programmers:

1. They participate in the presentation by,
2. Drawing on knowledge which is commonplace to them. Most important is tacit recognition by PLATO that they possess this knowledge. That is, if you can discuss CM word content, byte juxtaposition is no longer a new concept.

Noteworthy is that this type of interaction is not achieved through a test situation which measures the analyst's recall. The analyst is allowed to interact with the system as an equal. The analyst and the PLATO system recognize each other's common frame of reference, and this produces a feeling of comfort which aids in the learning process. It might be mentioned in passing that with systems analysts this appearance of mutual respect is quite important. After all, it is they or people like them who "breathe life" into software; and for any system to

approach them as anything less than at least "equal" borders on blasphemy.

Dialogue is also a desirable strategy. The only risk I see, and it is minimal, is the frustration that accompanies too much keyboard input. Those who can't type eventually rebel at being required to demonstrate a nonmastered unrelated skill like typing to accomplish mastery of the material. This situation leads me to conclude that presently, touch interaction holds the most promise.

PERSONAL BUT NOT IDIOMATIC

Some courseware writers fall into a trap while attempting to communicate with analysts in a casual dialogue. This is especially likely to occur in the reinforcement and hint material associated with response judging. Expressions such as "far out," "right on," "groovy," and "you got it, baby" are typically inappropriate for analysts. Much preferred is a response which is substantive, i.e.: "that's correct, and remember, B registers are only 18 bits long."

While idiomatic responses are appropriate in some circumstances, they are perceived by analysts as unprofessional, beneath the technical level of the subject matter; and in some cases they are perceived as abusive.

TASK ORIENTED

Field analysts tend to be task oriented. Their enthusiasm and motivation are kept high by the challenge of a problem to solve. Generally speaking, the problem should challenge their creativity and powers of logic. DOING something is very important. Against this background, a necessary element of a successful lesson is problem solving, which allows the analyst to tinker or do something other than answer questions. Among analysts, the ability to do is more highly regarded than the ability to know.

A group of lessons which employs this technique quite well is the CPU COMPASS curriculum. The material is well received by analysts partly because of the COMPASS simulator it uses. Student analysts can see there is more than one solution to any given problem and busy themselves in COMPASS coding to demonstrate their comprehension.

CREATIVE

Analysts are creative individuals. Rightly or wrongly, they perceive themselves as artisans of a highly creative craft. When placed in front of a terminal, they engage in an evaluation process. They judge the material they view against their own creative capabilities. In other words, a lesson is judged not only by its technical content, but also by how well it measures up to some arbitrary measure of artisan creativity.

Student analysts will mentally try to dissect the software behind the screen images. From this dissection comes a respect or lack thereof for the lesson author. If an author loses the student's respect, it is doubtful that the material will be of much value, regardless of its accuracy.

MODULAR

Analysts prefer modular lessons, and in this regard they are no different from any other student. CAI material should be broken up into logical modules no longer than 20 minutes' contact time. Bookmarks are a great frustration reliever, and analysts do appreciate them.

SUMMARY

While discussing PLATO-based analyst training, I hope to have provided a set of rational guides for the development of CAI material targeted for analysts. Any strategy an individual author settles upon must consider the analyst's self-perception and the unique requirements that accompany such a perception. Keeping this in mind will go a long way toward developing acceptable and effective CBE material for analysts.

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[1] G. M. Weinberg, The Psychology of Computer Programming (New York: Van Nostrand Reinhold Company, 1971).

When PLATO Knows Latin: Benefits of Letting the Computer Inflect the Forms

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University of Delaware

ABSTRACT

The Delaware PLATO Latin Curriculum, now near completion after three years of development, combines the use of drivers with the use of routines to inflect the variable parts of speech. These routines enable the computer to offer an error markup based on the structural elements of the individual words--"intelligent" markup very similar to that which a human teacher would give. The routines also make possible lessons tailored by the student to fit individual skill levels and content requirements. Variety, efficiency, flexibility, and precision are all enhanced.

The title of this paper, long as it is, is still inadequate. The benefit for Latin instruction comes from a combination of two elements: an algorithm that inflects the variable parts of speech in Latin, and separation of the lesson contents from the driver. The latter is a common CAI technique, but the former has rarely if ever been done for instructional purposes. Together they yield solid benefits not only for Latin but for instruction in other languages as well. Let me describe briefly the PLATO Latin Curriculum which employs these principles and then point out the specific advantages that have accrued. Finally I will comment briefly on possible applications of the approach to other languages.

The PLATO Latin project at the University of Delaware began in the spring of 1977. Its overall purpose was to design a curriculum to supplement the first year of instruction much as a tutor does: identifying student weaknesses, assigning remedial work, checking exercises, helping the student to find and correct his errors, and supervising skill-building work. The first phase was the development of a pair of lessons on Latin verb forms. Since the lessons would have to deal with all finite verb forms taught in the first year--some 120 forms in each of five conjugations--it was clear that those lessons would need the ability to inflect the verb.

The first of them is called Verb Factory, a diagnostic-remedial lesson which behaves as follows. The student is asked to type the Latin equivalent of an English verb phrase. Partially correct answers are analyzed into stem, tense/mood sign and personal ending, with comments and hints provided which are based on the word segment in which the error occurred. Since the computer "knows" the rules by which Latin verbs are formed from these three elements, it can separate the student's response into the same elements and judge it morpheme by morpheme. This stage of analysis also includes eight checks for specific common errors, such as use of the wrong tense/mood sign--for example, future (-bi-) for imperfect (-ba-). The student may have his incorrect response "scanned" if he likes; that is, the computer will compare it with each one of the forms of the target verb in turn to determine whether or not it is some genuine form of that verb, and if so, just which form.

The name of the lesson, Verb Factory, comes from the major help sequence in which a student who is baffled by some form is given a series of questions and hints to

student obtains more information about individual words and types a new attempt--an important convenience when responses of fifteen or eighteen words are involved.

It should be noted that this lesson does not make use of computer routines to inflect the variable parts of speech as the other lessons in the curriculum do; rather it uses the computer to draw diverse information rapidly from a rather large database at the student's command. This kind of activity was frequently requested by students who used the earlier lessons, and it is a valuable complement to the last lesson in the project to date, the sentence analysis lesson.

That lesson requires a student to make a grammatical identification of the words in a Latin sentence, one at a time in context; for example, take the sentence Multi pueri libros legunt: Many boys read books. When this sentence is displayed, eight touch positions are displayed beneath it--one for each of the eight parts of speech. The student begins with the first word multi which he identifies correctly as an adjective. Immediately a second row of touch positions is displayed below the first row and he must indicate what kind of adjective it is: regular, demonstrative, relative, interrogative, and so on. When he touches "regular", a third set of touch points is plotted and he must identify the word by number, gender, and case. This last stage differs sharply from the first two because in those stages a wrong answer would not be accepted; but in this stage any input is received without a judgment. That is, if the student identifies multi as nominative singular masculine, though it is plural in this sentence, the computer will accept that input. Then it inflects the stem of that word according to the student's input and displays the resulting word--multus--under the target word, multi. The goal, as can be inferred from this much, is to duplicate the sentence in its entirety by identifying the grammatical form of each word in turn. In the case of words which vary in form--that is, nouns, adjectives, pronouns and verbs--the computer uses appropriate routines to inflect them, thus giving the student a unique and precise kind of feedback from his responses. Successful completion of each sentence in the series is rewarded by a look at the English translation of that sentence. This practice reinforces the principle that proper analysis of any sentence is tantamount to translation of it; the act of translation is simple by comparison, and follows easily from analysis.

Thus the two sentence lessons complement one another, since in the first, analysis is provided and the student concentrates on translation; and in the second, a translation is provided after the student has correctly analyzed the grammatical structure.

That is the current state of the PLATO Latin project at Delaware; the two sentence lessons are undergoing testing by students during the present academic year. One more lesson is planned to complete the package. It will attempt to teach the techniques that are used in translating a sentence from Latin. Its chief emphasis will be to help a student distinguish primary from subordinate elements in the sentence, identifying subordinate clauses and other major modifiers in order to mask them long enough to reveal the main clause.

I hope to have a pilot version working by the end of the academic year.

My experience suggests that combining routines which inflect the variable parts of speech with driver lessons yields a very powerful tool for both language instruction and pedagogical research. The following are some of my reasons for this view:

1. Variety of material is greatly increased. The noun-adjective phrase lesson, for example, can produce 40,000 distinct phrases from a common less than 300 words in length. This of course means that repeated use of such lessons is both practical and desirable. One noun-adjective lesson covers all forms encountered in the first year of college work.

2. Efficiency is enhanced as well. That same noun-adjective lesson requires only about 4000 words of ECS while producing ten times that number of practice phrases. Since students continue to use the same lesson throughout the year, no problem of ECS occurs if some students work ahead or review.

3. The skill level in the verb and the noun-adjective lessons can be set by the student, thus permitting him to remain challenged throughout the year. Review of problem areas can be precisely tailored

help him establish the grammatical form of the verb he needs to produce. As he proceeds through this sequence the correct form is assembled on the display panel for the student one segment at a time: stem, tense/mood sign, personal ending.

At the end of each exercise of twenty items the student sees a tabular display of his errors: so many third person singulars wrong, so many future tense, etc. This is his prescription for practice in the companion lesson, Cursus Honorum. In that lesson he can select the conjugations and forms of the verb he wants to practice, or even the specific verbs. That is, he may work with a random selection of verbs from the conjugation or conjugations of his choice or he may drill on any one verb he wants, even one not previously in the computer's memory. In this last instance, a student inserts the principal parts of the desired verb and the computer can then quiz him on any of its 120 finite forms. But whether he uses one verb or a number of them, he need practice only those specific forms he selects--all third person plurals, for example, or only passive forms, or the pluperfect subjunctive. Once these parameters have been set, PLATO makes a choice of one form at random and challenges the student to type it. A timer, also set by the student, and a point system, keep a gentle pressure on him to do his best. As his score increases, he advances through the various levels of the Cursus Honorum, the ladder of Roman political offices, from Military Tribune all the way to Censor.

An alternate version of this lesson is also in use. In it the student does not type the form, but sees the correct form displayed and must parse it by touching the appropriate items of a grammatical chart. PLATO uses this input to inflect the target verb and displays the result for comparison with the correct word. Thus if a student identifies a second person singular form as second person plural, PLATO shows him how the plural of that verb would look, and he can recognize his error and make corrections.

The second phase of the project, begun in the summer of 1978, applied the experience gained with verbs to nouns and adjectives, which are also inflected in Latin. The result was a lesson that offers practice in forming and in parsing phrases consisting of a noun and an adjective. As was true with verbs, the key to the program is a routine to inflect these parts of speech according to Latin linguistic principles. The routine can be used not only to produce a wide variety of phrases from a relatively small database of stems, but also to judge student responses and indicate whether an error is due to a faulty stem or an incorrect ending in the noun or the adjective.

Other structural similarities to the verb lessons betray the ancestry of this lesson: students choose the declensions from which the noun stems are to be drawn, and do the same for adjectives. They also select the cases and numbers which will be included in the drill. Then PLATO asks the student to type some specific form--say the dative singular--of a phrase made from a randomly-paired noun stem and adjective stem. Incorrect answers can be broken down by the computer to pinpoint the location of the error to stem or ending of either word. As with the verb lessons, an alternate version displays the correct form and requires the student to parse it on the grammatical chart.

Phase three of the project began in the summer of 1979 with the aid of a grant from the University of Delaware's Center for Teaching Effectiveness. This was the most challenging phase of the project: the design of two complementary lessons in sentence translation and sentence analysis.

The translation lesson provides all reference information necessary for translating from Latin to English, thus allowing the student to concentrate on the translation process without the distractions caused by the need to refer to dictionaries and grammar charts. A Latin sentence is displayed at the top of the screen; by touching any word in the sentence the student can obtain the dictionary entry, the dictionary meaning, the grammatical form, or the syntax of that word. Thus he can have his technical questions answered almost as quickly as he can form them, and he is free to focus on integrating the information into an understanding of the meaning of the entire sentence. When ready, he types his translation in the usual manner. An unsatisfactory translation can be left on the screen for comparison purposes while the

to each student's needs.

4. The use of separate drivers and content permits the entire package to be made compatible with any textbook which happens to be in use at a given institution.

5. Real error analysis can be done, and this of two kinds: first is the flexible and precise feedback given to the student at the moment. That feedback is keyed to the structural principles of the language and is of great value in teaching the student to think of the words in a structural way, e.g., verbs as composed of stem, tense/mood sign, and ending. The second kind of analysis can be done by the instructor from the data collected by these lessons. Precise information can be obtained on just where errors occur at various stages in the verb curriculum, or in that of nouns or adjectives. For example, even the early data indicate that the tense/mood sign becomes a source of trouble when third and fourth conjugation verbs are introduced. Such information, because it is based on the word segment where the error occurred, is more manageable and more valuable for pedagogical study than an amassing of all the individual wrong responses.

The applications of the approach outlined here are not unlimited; one should not claim to have found the golden key. Certainly the technique can be refined further for use in Latin instruction. Certainly, too, the same principles will find ready application to ancient Greek, which is even more highly inflected than is Latin. In fact, the element of inflection is probably the most significant one in the equation. Languages should find this technique feasible almost in direct proportion to the degree of inflection the language displays. Sanskrit, Norwegian, and German would thus find more promise in using it than would French or English. But with these reservations in mind, I venture to suggest that teaching PLATO to inflect the forms will significantly enhance PLATO's ability to teach those forms.

CBT Breaks Ground In The Oilfield

Thomas C. Rebstock

Control Data Corporation

ABSTRACT

The energy boom of the 1970's created a tremendous demand for highly skilled workers in the oil and gas drilling industry. One manufacturer of solids control equipment used on drilling rigs, SWECO, Inc., responded to its training needs by developing a Computer Based Training program aimed at its new-hire field service representatives. Utilizing PLATO Learning Management and PLATO Assisted Learning activities, SWECO now delivers individualized instruction on topics related to the fundamentals of drilling mud, solids control, and specific equipment in its product line. The course has provided relief from the inherent constraints of traditional training and has been cost-effectively implemented. This precedent suggests that similar applications of CBT could be justified throughout the energy industry.

INTRODUCTION

The energy crisis of the 1970's brought about a phenomenal growth in oil and gas drilling, both domestically and abroad. In conjunction with this increased exploratory activity came new equipment designed to streamline the drilling process and control inflationary costs. One group of such new products was a line of advanced solids control equipment introduced in 1973 by SWECO, Inc., who for thirty years had been a major manufacturer of industrial screening devices. Along with SWECO's new products was a commitment to service its equipment on the customers' rigs, and thus was born a need for SWECO to field a crew of service representatives. As the product line expanded, the geographic dispersement of these units spread worldwide, and the demands of total customer service grew more complex, SWECO turned to, and found an answer in, Computer Based Training.

JUSTIFICATION OF CBT

Why CBT? First of all, a large number of competent servicemen had to be found quickly to keep up with rapidly expanding sales, and the bulk of these positions were filled by new-hires. Of course on-the-job training has always been the easiest, most common way of breaking in new personnel in the oilfield, and SWECO did rely largely on OJT. However, this sort of orientation is usually an experience in learning by mistake, which can be devastating on customer satisfaction, sales and profits. That initial approach, coupled with the traditionally nomadic nature of the oilpatch type who formed a large share of those first hired, left SWECO with a high turnover rate among its earliest service representatives, which in turn compounded training requirements.

SWECO did have a Technical Services Manager at Oilfield Service (OFS) headquarters in Houston who could solve just about any problem or show anybody how to fix anything, but only one person or problem at a time. When this manager tried to conduct training seminars for the service representatives, he encountered all the traditional shortcomings of common instruction:

- difficulty in scheduling classes in correspondence with hiring procedures;
- widely varying entry level knowledge and skills;
- no means of accomodating individual learning rates;

- no practical means of assessing competencies gained;
- having to pull entire class from the work force at once;
- high travel and expense costs;
- commitment of instructor time to present the same material again and again.

Having experienced these frustrations in the classroom and in the field, the high turnover rate continuing in the face of booming sales and intense demand for highly trained service representatives, SWECO sought out and successfully implemented a CBT program.

CBT PROGRAM

At the request of and with the subject matter expertise provided by SWECO, Inc., Oilfield Service Division, Control Data Education Company designed, developed and programmed an individualized, competency-based training course onto its Control Data PLATO system. This course, "Introduction to SWECO Solids Control," intended for a target population of new-hire field service representatives, averages approximately four hours in length and is deliverable in any of the over sixty Control Data Learning Centers worldwide. This program utilizes the computer both for management and delivery of training.

Structure and management are provided by the PLATO Learning Management (PLM) hierarchy, which allows easy administration of truly individualized training. The Needs and Instructional Task Analyses revealed four main subject areas which were covered in this initial course:

- Fundamentals of drilling mud
- Benefits of solids control
- Mechanical equipment used to control drilled solids
- SWECO Sand Separator.

These four topics were organized into a sequence of twelve PLM modules, including a total of thirty-five instructional objectives and a pool of over two hundred and fifty test questions used to assess student mastery of the objectives. As trainees demonstrate mastery of the objectives, they are allowed to progress to the next module. If students show a deficiency in one or more objectives, PLM generates a study assignment based on unmastered objectives--see Figure 1, Inidividualized Instruction Model[1].

The learning resources are either readings from an eighty-five page trainee manual developed especially for the course, or PLATO Assisted Learning (PAL) activities. The manual is organized according to the twelve PLM modules and was intended as a reference guide which the trainees take with them upon completion of the course. The seven PAL lessons represent the other application of the computer besides PLM: actual delivery of training via interactive tutorial, drill and practice, problem solving and simulation modes of instruction.

The tutorial lessons are intended to introduce basic drilling concepts, utilizing PLATO's graphics for animation of downhole operations, and new information dealing with specific equipment. Drill and practice mode is used mainly for instruction related to matching-type objectives and for equipment parts identification drills. As seen in Figure 2, high level graphic renderings of the SWECO equipment were produced on the PLATO terminal, the parts labelled and touch-active boxes used for student identification of the parts. This touch feature was utilized throughout the PAL lessons and the PLM tests due to the poor typing skills of the target population and is vital to the program's success.

In addition to teaching parts identification, SWECO also wanted a means to demonstrate the internal processes at work within its Sand Separator, so a PAL lesson was developed to provide this simulation feature. Using a partially-cutaway view (see Figure 3), the paths of different drilled solids particles are shown within the separator, as different particles take different paths through the equipment depending on size. The lesson provides an excellent means of demonstrating the dynamics involved in the two-stage separation process unique to this SWECO equipment.

Perhaps the trainees' favorite PAL lesson is a drilling simulation in which the student plays the role of a field service representative and has to solve problems and make decisions in the course of a drilling operation. As seen in Figure 4, one of the typical questions is whether to change solids control equipment during various stages of the drilling. As the student interacts with the problems, drilling proceeds downward. If a trainee makes five mistakes, the operation will fail and the rig will have to be skidded over and drilling started again, which would be very expensive and unsatisfactory in a real drilling situation. If the trainee solves his problems with fewer than five errors, the drill bit will strike oil at eighteen thousand feet and the operation is considered a success. Highly interactive lessons such as this provide a motivating way for the trainee

to gain valuable and realistic job-related experience.

RESULTS/FUTURE CONSIDERATIONS

Since this program was so recently implemented (2Q '79), it is too early to evaluate its impact in quantifiable terms such as employee turnover rates. However, as of the time of this writing, more than seventy SWECO service representatives, managers, and sales representatives from around the world have completed the course, and so far the feedback is unanimous in terms of its providing relevant, consistent and understandable training. The mere existence of the program shows the employees that their company cares about them and considers them important enough to justify a significant investment in training dollars.

The benefits which are being attained through this training program are in fact not unique to the oilfield, but are direct results of individualized, criterion-referenced CBT:

- delivery of consistent content;
- significant reduction in the time required to attain competencies;
- ensured proficiencies through mastery-based criteria;
- improved attitudes toward jobs and training;
- reduced travel and expense costs;
- convenient scheduling for training;
- improved productivity/fewer on-the-job errors;
- documented records of each trainee's performance;
- valuable feedback for curriculum enhancements.

SWECO is sufficiently satisfied with the progress toward these benefits that it has made a commitment at the Chairman of the Board level to continue and expand this approach to training. Plans have been made for development of a Phase II course which will include more advanced topics such as electrical and mechanical troubleshooting. This program will most likely include color videotapes as learning resources, in addition to a manual, PAL lessons and PLM management. Some revisions will also be made to the existing course, such as a name change from the tradename "sand separator" to the generic term "mud cleaner," and perhaps a Spanish version of the course aimed at delivery in Mexico. In addition to continuing to rely on the Control Data learning centers for delivery of the course, SWECO has installed a PLATO terminal at its new OFS division headquarters in Austin, Texas, for enhanced delivery capabilities, administrative purposes, and the acquisition of in-house expertise related to PLATO courseware development. SWECO also plans to make the course available to its customers to train their personnel and to support its marketing program.

CONCLUSION

Since 1973 SWECO's OFS Division has attained a preeminent position in solids control equipment, and its commitment to CBT should help considerably in maintaining that stature through well-serviced equipment. The precedent set by this "Introduction to Solids Control" course applies not only to SWECO, but to the entire energy industry. The training needs addressed by this approach and the resultant benefits apply throughout the drilling industry, the huge oil tool business, mining operations involving coal, uranium and minerals, the new synthetic fuel industry, and on and on. Wherever there exists a geographically-dispersed demand for equipment that must be serviced in the field, this type of CBT can be implemented successfully and cost-effectively. The ground has barely been broken, but based on initial exploration, this area of CBT reeks of huge untapped reserves.

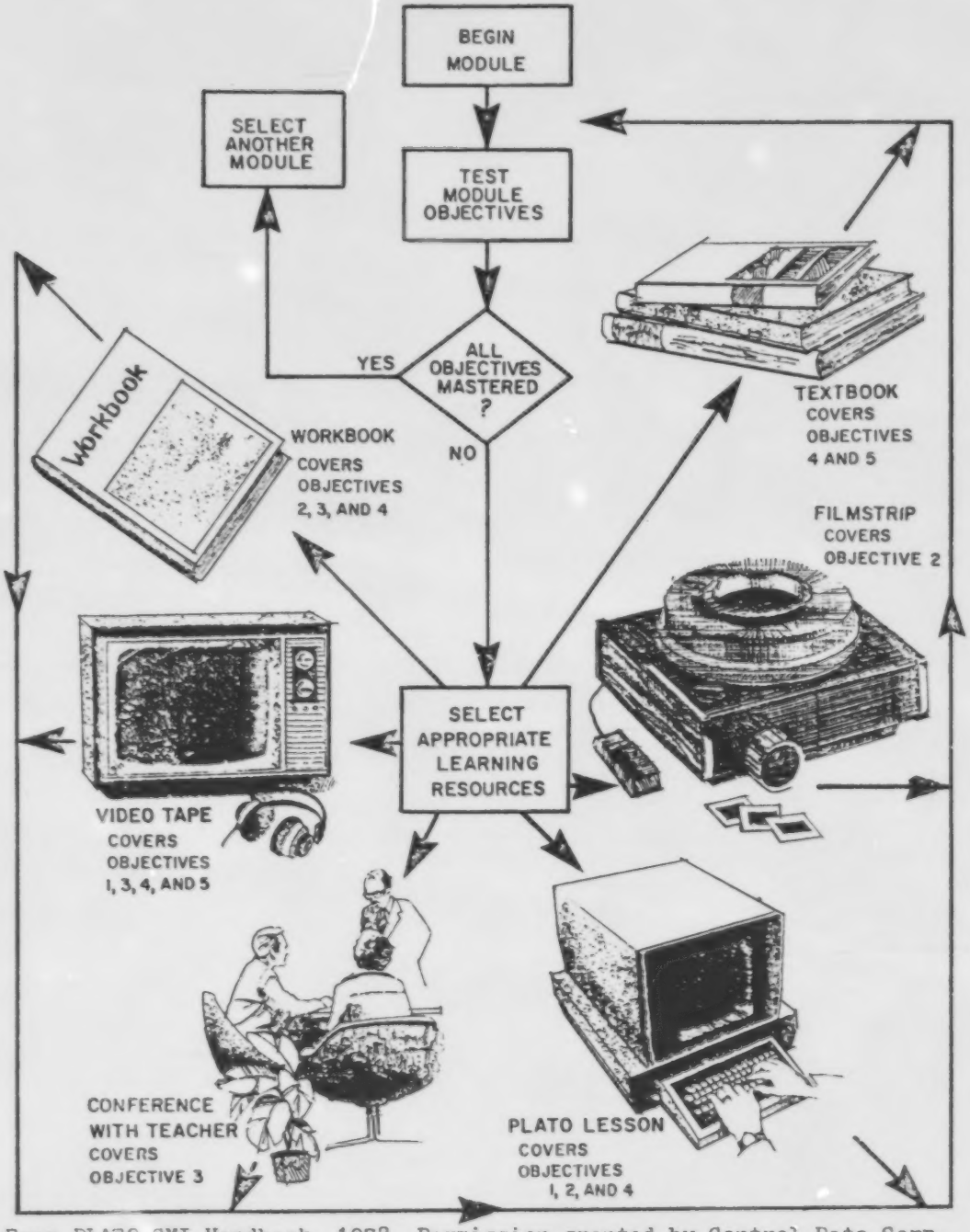
NOTES

[1] PLATO CMI Handbook (Minneapolis: Control Data Corporation, 1978), p. i.

ACKNOWLEDGEMENT

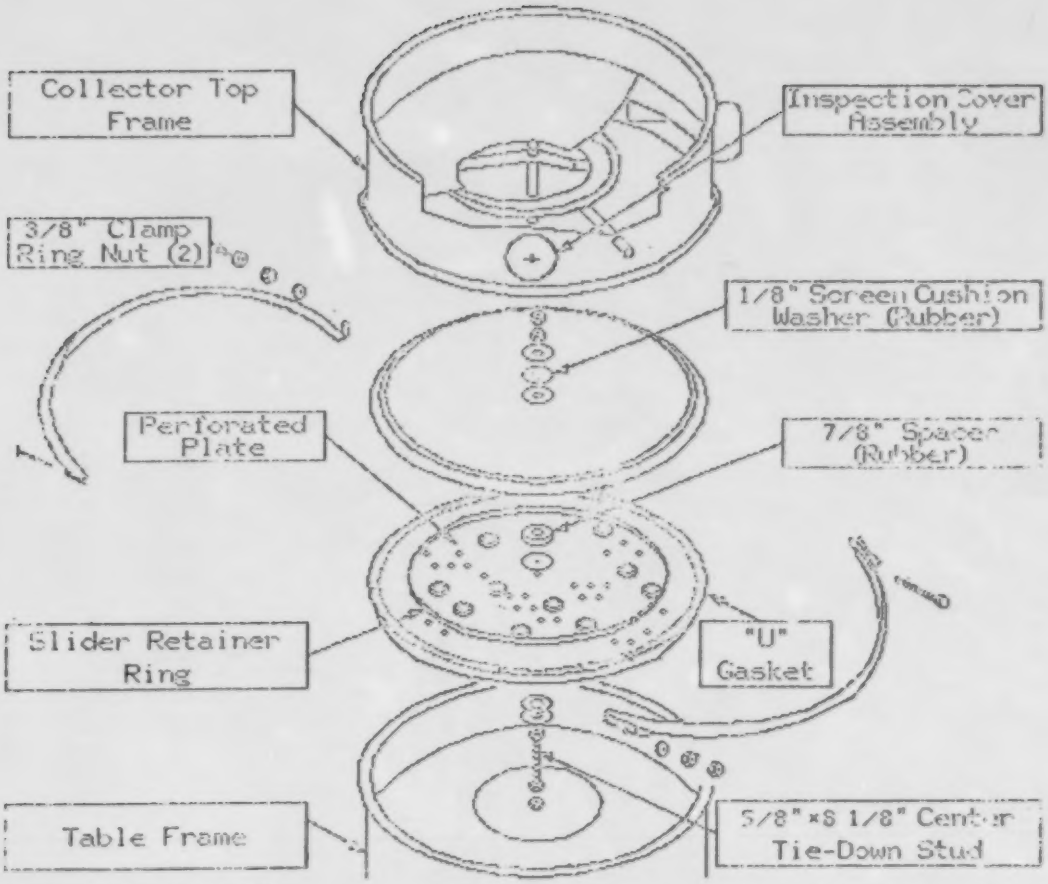
The author wishes to express his appreciation for the vision and commitment shown by SWECO, Inc., Oilfield Service Division, which made this venture possible, and to the marketing, management, educational consulting, and learning center staffs of Control Data Corporation, Southwest Region, whose combined efforts resulted in the development and successful implementation of this CBT program.

FIGURE 1



From PLATO CMI Handbook, 1978, Permission granted by Control Data Corp.

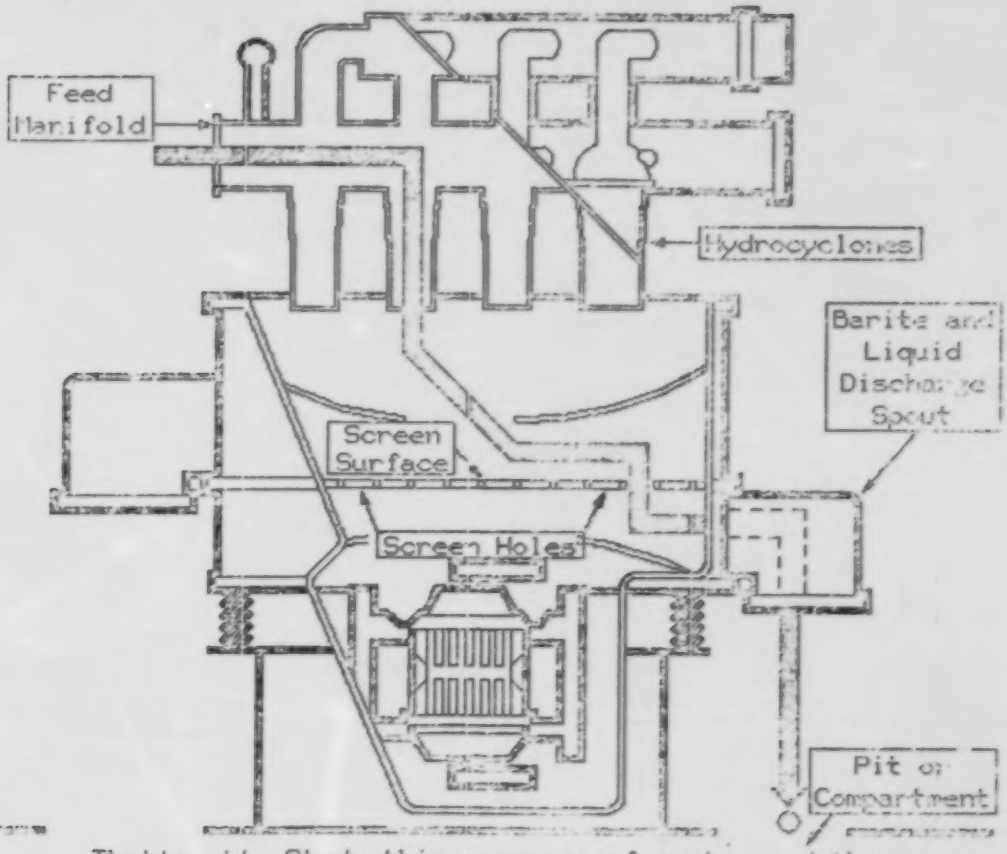
FIGURE 2



Very Good!
Study this drawing and these parts and then press [NEXT] or touch the screen when you are ready to move on to another part of the lesson.

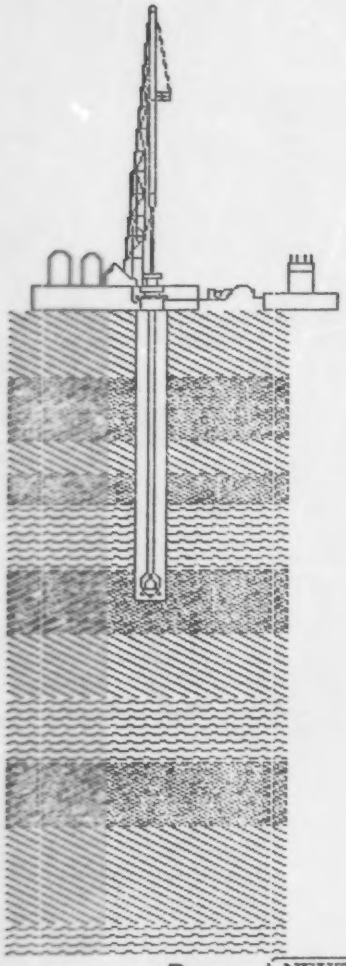
FIGURE 3

Observe the path of a MEDIUMSIZED particle:



That's it! Study this sequence of parts, and then press (NEXT) or touch the screen to try your own hand at tracing this path.

FIGURE 4



At a depth of 10,000 feet the bit has drilled into high-pressure, gas-bearing sand, which has required a change to highly treated chemical mud. Barite has been added to increase the mud density to 14 pounds per gallon.

Do you need to change the type of solids control equipment?

YES

NO

You bet you do! Since you're now drilling with weighted mud, a change in solids removal equipment is necessary.

Press NEXT or touch the screen to continue

"GOOD JUDGMENT" AND THE COMPUTER

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ABSTRACT

Whatever the phrase means, "good judgment" is one of the qualities we all want, and want in others. Though almost never absent from a personnel recommendation, the question of whether an individual has good judgment is rarely addressed as an educational objective. One reason is that few people can agree on what it is. Recently, however, some progress has occurred in quantifying what we mean by judgment (Winkler, 1967a, 1967b).

One approach to developing good judgment is to use a particular kind of confidence testing, called valid or admissible confidence testing because it assures that students will provide an accurate picture of their confidence level on test questions. The results of this procedure reveal in quantitative terms a student's ability to judge the value of his or her knowledge. The procedure reveals good judgment in the same sense that we speak of a weather forecaster's good judgment in predicting rain or an oddsmaker's good judgment in predicting the outcome of some contest.

Surprisingly, valid confidence testing has failed to attract many conventional or computer-based educators. A few isolated projects have used it, but a combination of factors have kept most teachers ignorant of its potential contribution to the learning process. It is the aim of this paper to explain and illustrate valid confidence testing, its use in forming good judgment, and the role of the computer in making this technique generally available.

The Rationale for Valid Confidence Testing

Confidence testing is the use of items that require the student directly or indirectly to assign to each item response a number that indicates a level of confidence in the correctness of the response. The number is sometimes a rating or weight, other times a value that represents a payoff for the response, but invariably confidence testing requires a response that involves something more than selecting an answer. It is the "something more" that provides information about the quality of a student's judgment.

Confidence testing was originally attractive because it hoped to find in the extra information ways to improve reliability and validity and to shorten tests. As it turned out, the extra information has proved troublesome because it includes a personality factor ("general confidence") that contaminates the results (Jacobs, 1971 Hansen, 1971; Swineford, 1938, 1941; Echtermacht, 1972).

Valid confidence testing, also called admissible probability measurement, (Shuford et al, 1966) provides a theoretical basis for controlling unwanted personality variables. First, it eliminates the rationale for guessing by requiring honest reporting of confidence levels in order to maximize expected score. In other words, the payoff to the student is higher over the long run by admitting uncertainty than by hiding it. Such a scoring system is called reproducing because reported confidence levels (probabilities) honestly reflect actual subjective (personal) probabilities.

Non-reproducing procedures for confidence testing invite suspicion about the validity of the results. Particularly suspect is the practice of asking the question, then asking the student to rate the level of confidence in the response. Besides overlooking the usual problems of self-report, this practice fails to keep

the student who guesses from hiding uncertainty by an inflated self-rating.

The second way valid confidence testing prevents contamination of the results is by quantifying "general confidence" so that it can be separated from the knowledge score. Called realism (Shuford and Brown, 1975)this personailty factor represents the degree of bias between perceived and actual information, i.e. the tendency to distort what one knows in one of two directions: undervaluing or overvaluing. Another term one could use for this tendency is judgment. To look at a student's knowledge, one would want the adjusted score, with realism variations removed. To look at a student's judgment, one would want the amount and direction of deviation from perfect (unbiased) realism.

How Valid Confidence Testing Works

Before computers became available, valid confidence testing was either too complicated or too cumbersome for general use. Even now few educators are likely to bother with it until computers are as accessible as calculators. That day, however, is not far off. To develop supporting software we will need to understand just how valid confidence testing works.

The key to this new kind of testing is the scoring rule or payoff function. The payoff, or item score, usually has a range of 100 points, and the test score is the average of the item scores. The best payoff function currently known is logarithmic because it is a reproducing scoring rule and is suitable for tests with items having more than two alternatives (Shuford it al, 1966; Windler, 1969).

The logarithmic function operates on only the correct (or best) answer responses. The student responds with a number that implies a certain level of confidence or probability that an alternative is correct. Though the score is based only on the correct (best) answer probability, it is essential to the logarithmic function that the probabilities assigned to the item's alternatives add up to 1.0. A computer is the obvious way to live with this constraint, either by enforcing it on-line or by normalizing probabilities during a batch analysis.

Probabilities are usually indicated indirectly, as lengths of a line, number of stars, or a point in a triangle. The reason for these physical representations of probabilities, besides giving aid in the difficult task of thinking probabilistically, is to insure that probabilities total to 1.0. For example, given 12 stars and a four-choice item, students favoring choice B with a .75 probability assign nine stars to B and have three left over to distribute among A, C, and D. The notion of distributing probabilities is perhaps the critical concept to teach to students in order to break long-established habits of overvaluing information inculcated by conventional single-choice testing.

In order to teach students to distribute probabilities when they have only partial knowledge about a test item, the student must be given an incentive, which is the logarithmic payoff. Otherwise the student is best advised to guess by assigning all probability to a single choice (Shuford and Brown, 1975; Murphy and Winkler, 1970). To become an incentive, the payoff must be clear to the student for each level of probability.

A number of approaches have been used to impress upon students the payoff for the probabilities they assign to item alternatives. The SCoRule response aid (Shuford, 1970), a set of sliding cardboard panels, translates a line length to a number between 0 and 100 representing the logarithmic payoff. (1) This device forces the student to respond with payoff values rather than probabilities so that the connection between probability (line length) and payoff is clear. This connection is nonlinear; hence the incentive to reveal subjective probability. Low probability levels have surprisingly high payofts, while payoffs for high probability levels rise in small increments.

For example, on the four-choice item above, the .75 probability would result in an item score of 94 if B turned out to be correct, but with a .25 probability assigned to correct answer A the score would be 70. Even more dramatically, raising .75 to .85 on correct answer A would increase the payoff by only 2 points, but raising .0 to .10 on correct answer C would increase the payoff by 50 points! The most advantageous strategy, then, is to lower the probability assigned to the preferred response if any uncertainty exists about its correctness, then raise the probabilities assigned to less favored but possibly correct alternatives. One thereby trades the possible loss of a little payoff for the possible gain of a relatively large payoff if a less favored alternative turns out to be correct.

The SCoRule has two serious weaknesses: (1) it often meets resistance as too complex, too cumbersome, and too time-consuming, and (2) it allows students to respond incorrectly either because the sliding panels overlap or simply because

the students cheat. Used with a computer, however, the SCoRule is less confusing and payoffs can be checked to be sure the corresponding probabilities total to 1.0.

A simpler alternative to the SCoRule is the star system (DeFinetti, 1965). While SCoRule line lengths can represent any level of probability, stars stand for a limited set of probability levels. Originally DeFinetti proposed five stars, but Brennan (1973) suggested 12 since most test items have two, three, or four alternatives. In each case 12 stars allows the student to indicate equal probability for each alternative ("zero knowledge"). Sets of stars have nonlinear payoffs; e.g. nine stars in the item above yields a score of 94, three stars 70, etc. Brennan's computer program DEC-TEST normalizes star assignments if stars do not total to the full set, and he created an optical scan sheet to simplify test scoring. A major problem with the star system is that the student may not recognize the implicit payoff values, thereby weakening the incentive to reveal subjective probabilities.

The simplest response mode, perhaps, is the triangle in which each vertex represents an item alternative (Shuford and Brown, 1975; Rippey and Voytovich, 1979). By selecting only one point in the triangle, the student indicates a level of probability for each of the three alternatives by the distance of the point from each vertex. The payoffs for each alternative are available from an accompanying chart if testing is done off-line; if on-line, the computer displays the payoff at the terminal and asks for confirmation.

The triangle, of course is limited to three-choice items. However, by increasing the number of items so that the total number of alternatives on the test remains the same, one can achieve even better reliability than one would get with items having more alternatives (Grier, 1975). Still, teachers often prefer different types of items. Off-line testing with the triangle also raises again the question of whether the student takes payoffs into account when responding.

Separating Knowledge and Judgment

Where the computer really begins to play an invaluable role for valid confidence testing is in the area of realism training, a method for helping to form good judgment that uses a new kind of feedback. This feedback is possible because valid confidence testing can separate knowledge from a type of judgment that is called realism.

The realism score that accompanies the test score shows how well reported probability levels compare with frequency of success at those levels. A student who assigns high confidence to alternatives that are generally incorrect performs unrealistically when using that level of confidence. By grouping levels into intervals (usually ten), plotting the success ratio for each interval (number of times correct over number of times used), and drawing a least-squares line through these points, one obtains the realism slope, or tendency over the whole test to respond realistically. A slope less than 1.0 means that success ratios at high confidence levels fall below perfect realism; the student overvalues information. Less commonly, a slope greater than 1.0 shows undervalued information.

The realism score (slope plus direction) reveals the general quality of the student's judgment, which may mask how much the student actually knows. It is possible to eliminate realism variation from test scores by computing adjusted probabilities. This is done for each item by applying the realism function (intercept plus the product of slope and probability level) to the original probability level assigned to the correct answer. Item scores recalculated using adjusted probabilities then combine to yield an adjusted score that shows how one would have scored with perfect realism.

Because perfect realism maximizes test scores, this new score will always exceed the old one. The difference between them is called the realism improvement score (Rippey and Voytovich, 1979), though a more descriptive name might be the distorted judgment score since it shows how much the student suffers by responding unrealistically. The point of a realism training program is to reduce the distorted judgment score to zero.

Valid confidence testing therefore removes the confounding effect of differences in judgment by adjusting test scores. At the same time, however, it is possible to reduce this effect by training students to form good judgment (Rippey, 1979; McMullen, 1974). The challenge to educators is to find out how best to provide that training, and it is obvious that computers are essential. Few teachers either want to or are competent to perform the necessary calculations, but the real contribution of the computer may be in providing interactive graphs and games that make the training appealing.

In a world of exploding information, valid confidence testing by computer at last enables students to do more than gain knowledge. They can now learn how to use

good judgment in dealing with the knowledge they lack.

FOOTNOTE

(1) The SCoRule formula for converting correct answer probability p into item score S is $S = 50 \log p + 100$.

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THE THREE-PRONGED COMPUTER-BASED COURSE DEVELOPMENT PROCESS

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ABSTRACT

The development of computer-based training materials is at least as complex as the development of materials in other formats. Several different skills are needed, including subject matter expertise, instructional and media design, and computer programming. This paper describes the components of the required skills, explains why they are needed, and discusses how people who possess the skills interact to produce computer-based training materials at Digital Equipment Corporation.

Development of computer-based training materials requires at least three types of expertise. Subject matter experts are needed who can understand the material to assure that the courseware is technically correct. Instructional media specialists are needed to assure that the computer media is used appropriately and creatively. And computer programmers are needed to assure that the processor is used efficiently and intelligently. For large projects, a project manager is also needed to set goals and schedules and to assure that there is ample communication between the various development team members.

This paper discusses the types of skills that each of these specialists possesses and how they work together to produce computer-based training materials at Digital.

Subject Matter Experts

While training course developers are the people who must teach others, there is seldom anyone to teach the course developers. At Digital, hardware and software training must usually be available as soon as the first systems are shipped to customers. Course developers must therefore be able to talk the language of hardware or software engineers and interface with them to extract the material that students need to know. These people must understand computer systems in depth, but they must also be sensitive to the needs of the target student population and sound educational practices.

Through interaction with many different people and prototype systems, course developers strive to become subject matter experts in the topic to be taught. They then work with the project manager and other team members to write "training specifications" for the courseware to be developed. These specifications include the objectives that students will be expected to achieve, an outline of the presentation strategy, and estimates of the project's schedule and costs.

Once the training specifications have been approved, the subject matter experts begin to develop materials for delivery via computer-based instructional techniques. In all cases, the subject matter experts review the technical accuracy of any materials produced independently by other team members.

Instructional Media Specialists

As an instructional medium, the computer has several unique characteristics. It can allow an instructional program to branch from one lesson to another so that courses can be individually tailored for each student. Student responses may take many forms so that the system as a whole is "human-engineered" and provides a friendly environment conducive to study.

And some of the characteristics of television can be mimicked by moving characters and graphics around on a terminal screen.

Effective use of these characteristics requires the skill of instructional media specialists trained in visual theory, human-engineering, educational psychology, and instructional systems development. The instructional media specialist works with the subject matter experts on an equal footing to plan the entire program and the types of interactions that students will have with the computer system.

As media specialists, these team members specify the type of media to be used for various topics (which may include non-computer media) and design displays for computer screens. As instructional specialists, they review the validity of the instructional strategies implemented by the other team members and administer developmental tests of prototype instructional materials.

Computer Programmers

There are a large number of computer-assisted instruction (CAI) "authoring languages" available on systems made by most computer manufacturers. These languages are usually designed so that they can be used by persons with little or no computer experience. When implementing large and sophisticated CAI applications, however, one often finds that these authoring languages are just not powerful enough or are too restrictive to do the types of processing needed. In addition, these languages often make inefficient use of the computer system.

Computer programmers are employed so that the full power of the host computer system can be exploited. The programmers may work in a high level authoring language, but they are expected to be able to use lower level languages, if necessary, to implement routines which the subject matter experts and instructional media specialists decide are necessary to achieve the objectives of the program. For example, in one of our computer-based courses we found it necessary to simulate the performance of the system editor under program control. While very difficult to do in the commonly available authoring languages, this task was programmed in BASIC-PLUS-2 with a reasonable amount of effort.

The presence of computer programmers to concentrate on implementation issues has other advantages. The subject matter experts are able to concentrate on what should be taught rather than how the computer will teach, and the instructional media specialists are able to concentrate on what is the most effective way to present that material rather than how hard it will be to implement that strategy on the computer. Programmers worth their salt never say "it can't be done", they just tell you that certain tasks take longer to program than others. It is the project manager's responsibility to set priorities and determine which strategies the team can afford to implement.

The computer programmers have one other very important job: they set up the database that will store student records and write routines to update and access this database. This task has received very little attention in the literature, but it is of vital importance to a fully operational computer-based training system. The programmers are expected to make the database management portion of the system powerful and efficient. It must provide enough data to evaluate the system fully, but it must not restrict the course developers or get in the student's way.

The Project Manager

The complexities of project management are often underestimated. Many steps are involved in bringing a computer-based training product to fruition. The subject matter must be researched. A proposal must be made to a funding agency. Plans must be drawn up and approved for technical accuracy and marketability. Schedules must be coordinated with various departments and persons outside of the authority of the training development organization. Instructional materials must be synchronized so that they look consistent, reviewed to assure that they meet applicable corporate standards, and critiqued for technical accuracy, instructional validity, and presentation style. Packaging must be designed and arrangements made for course duplication. And finally, the product must be presented to the market through public announcements, brochures, and advertising campaigns.

The job of the project manager is to set schedules and manage progress toward each of the project's milestones. This involves working with each member of the team to determine individual capabilities and estimate the number of man-hours necessary to complete each of the project's component tasks. The project manager also coordinates the course development with related projects in other corporate departments and is usually the sole team member to deal with marketing issues. In addition, it is the project manager's re-

sponsibility to review all of the materials produced by each of the team members to assure consistency of message and a smooth blend with other computer-based training products.

A Team Process

Computer-Based Course Development at Digital is a team process. It involves the blending of many talents and the cooperation of many people on a single project. The blend assures that the materials are not only technically correct and instructionally valid, but also that they make interesting use of the computer as an instructional medium and efficient use of the computer as a delivery system.

TEXAS INSTRUMENTS' HOME COMPUTER

John D'Angelo - Texas Instruments

INTRODUCTION

The Texas Instruments Home Computer was designed to be the layman's computer; priced as a consumer product for the home market. It's design is such that all one needs to know is where to turn it on and off and where to plug in the solid state software. Even with this simplicity, it is a useful and powerful tool for the serious computer user.

ARCHITECTURE

The main console contains a 9900 family member, 16 bit microprocessor, as its central processing unit (CPU). The total combined memory capacity currently offered is 80K bytes. This is apportioned as follows, 26K bytes of internal read only memory (ROM). Up to 38K bytes of external ROM memory in one plug-in Solid State Software Command module. 16K bytes internal random access memory (RAM). Programs and commands are entered through a 40-key full travel typewriter style keyboard. Overlays are supplied for second functions. The console is powered by a wall mounted transformer and consumes approximately 20 watts. An I/O or interface connector is provided on the right side of the console to connect up to three peripherals. This does not include the cassette connection, which is separate. The parallel I/O interface utilizes a 44-pin connector which provides all 9900 processor address, data and control signals to allow the peripheral to fully use the Home Computer as a processing element. Up to three peripherals can be connected "daisy chain" fashion. All address lines are extended through the peripherals to their right side. The diagram below shows this arrangement.

The architecture allows for future expansion. Up to 48K bytes can be addressed within one plug-in solid state software module. Additional RAM and ROM can be addressed at the I/O port in 16K byte increments up to whatever limit engineering and cost considerations allow. More than three peripherals can be addressed if provided with an I/O port expansion unit. Many or all of these features will be provided in the future as the market dictates.

At present, a color monitor display provides color and graphics capability. Sixteen colors are provided, including black, white and transparent. The resolution is 256 dots horizonally by 192 dots vertically. Each individual dot cannot be addressed, but can must be addressed as part of a character. Up to 128 characters can be software defined in BASIC. In machine language, which can only be loaded as Solid State Software, up to 256 characters and 32 "sprits" can be software defined. Sprites can be positioned on the display starting at any dot position, and if their background "color" is selected to be transparent then the "characters" they overlay will show through. 32 characters are displayed per line with 24 lines maximum. A built-in speaker on the monitor provides sound from the computer. The volume is controled by a volume control on the monitor. An audio output jack is also provided on the console. The color monitor does not contain a RF tuner, therefore, reception of commerical TV programming is not available. The video output is a NTSC conforming composite connected to the antenna lead-in of any conventional color or black and white TV receiver for display purposes. The possible future offering of such an RF modulator would of course be subject to FCC approval.

SOFTWARE

Solid State Software modules

Each module consists of a PC board which can contain one to seven ROM chips. Six of these chips can contain up to 6K bytes each, adding up to a maximum of 30K bytes. The other two chips must be a higher speed ROM technology and contain 4K bytes each raising the maximum to 38K bytes. The units come enclosed in a plastic case and slides into the opening located on the upper

right side of the console. This provides the consumer with instant access to the program(s) stored in the plug-in ROM module. When using the ROM modules, none of the 16K bytes of RAM is used for code; it is all available for read/write data space. Currently available are modules in home management/personal finance, education, and entertainment. Several publishing and game companies are interested in pursuing this mode of software development.

BASIC Language

The built-in TI BASIC in the 99/4 Home Computer is a full floating point American National Standard compatable BASIC interpreter which has 13-digit precision. The BASIC source program and data to be used by the BASIC interpreter are contained in the 16K built-in random access memory of the computer. None of this RAM memory is used for the Basic interpreter itself since that interpreter is contained entirely within the system's read only memory. Segments of BASIC programs may not be concatenated together but in-lin editing features are available with cursor control to facilitate easy modification of BASIC source code. TI BASIC contains 33 statements, 19 system functions, and 14 commands. Full string manipulation is available. Variable names of up to 15 characters are allowed with all 15 characters recognized. No restrictions exist on imbedding reserved words within long variable names. Hence, FORTUNE, STOPPER, and LETTER are acceptable names even though they contain "FOR", "STOP", and "LET" respectively. Three dimensional arrays of strings and numbers are used. Resequencing of BASIC programs is included. The BASIC interpreter contains mathematical and transcental functions including the capability to concatenate, segement, and position string variable.

The TI BASIC sound subprogram (CALL SOUND) allows the playing of tones over a five octave range. Up to three notes or musical tones may be used simultaneously. Duration and volume of the sound are also under user control. Duration ranges from 1 to 4272 milliseconds. Volume selections are scaled from 0 to 30. Both white noise and periodic noise can be generated to create special sound effects.

The foreground and background color of the character can be defined under program control. As stated earlier, 128 characters or graphic symbols can be defined, including the redifinition of the 64 default character set. Full graphics capability enables the user to place appropriate characters anywhere on the screen, or in rows, or in columns.

PERIPHERALS

Audio Cassette

One or two audio cassette recorder/ players can be plugged into the back of the console. Programs as well as data files can be written to either of the two cassette recorders but can be read from only one. Programs are recorded or played back at an effective rate of 600 baud. Once the save (SAVE) or load (OLD) command is given, the user is prompted on the screen for the remainder of the instructions. Volume settings are over a broad scale. A wide range of tape recorders are suggested, including several manufacturers and many models. A tape recorder is not supplied with the unit.

Disc

The Disk Memory peripheral is designed to provide fast mass storage of data records and computer programs. The disk peripheral consists of a disk controller and one or more attached disk drives. The disk controller will connect directly to the interface port of the 99/4 Home Computer. Attached through a cable from the disk controller are one to three disk drives, each of which contains the mechanism for reading and writing to 5 1/4 inche floppy disk media. The disk peripheral will utilize single side, single density drives, each containing about 90K bytes of formatted data and define 127 files. The mini-floppy controller accepts fixed and variable length records and sequential or relative files. Free disk space is automatically reassigned for user file allocation. Also a special Solid State Software module with utilities including disk and file maintenance commands is included with this system. The average access time for any of this data is about 500 milliseconds. Data access to read or write to these drives will be controlled by FILE COMMAND statements that are provided in TI BASIC.

RS232

The RS-232 Interface Adapter is designed to provide a proper interface to a wide variety of industrial standard peripherals which utilize the RS-232 interface. The unit provides outputs for two such compatible devices to be connected simultaneously. Standard DB-25 25 pin female connectors are used for connecting the external device. The RS-232 peripheral itself is powered from the 110 volt AC line and connects directly to the 99/4 interface port. Examples of the types of equipment that will operate with this industry standard interface include printers, terminals, modems, plotters and digitizers. Examples of printers that would be supported by this unit include the TI 733 ASR terminal which provides 80-column thermal print as well as computer controlled tape storage and the TI 810 Dot Matrix Impact Line Printer which provides plain paper output with line lengths up to 132 characters. Although the 99/4 does not have lower case defined, it can control a printer which does, and therefore provide printed output in both upper and lower case.

Thermal Printer

The 32-column Thermal Printer provides hard copy output at a speed of about 1 line per second. The peripheral is powered from the 110 volt line and plugs directly into the I/O interface port of the Home Computer. Printing is automatically generated by print statements written into a BASIC program or upon appropriate commands including in TI Solid-State Software modules. ON-OFF switch and paper advance keys are provided. Characters may be printed to the thermal printer or to the 13-inch video screen. Since characters can be defined with BASIC to have perticular dot combinations desired by the user, this capability can be utilized to create limited graphics using this printer. Due to the characteristics of the print heads used, only 5 X 7 dot combinations can be used with the printer whereas 8 X 8 dot combinations may be displayed on the color monitor.

Speech Synthesizer

The Speech Synthesis peripheral for the TI 99/4 Home Computer is designed to provide voice output under computer control. It uses essentially the same technology at the TI Speak and Spell and the TI Language Translator. The peripheral has a 250 word vocabulary with plug in capability for up to approximately 800 additional words. An associated plug-in Command Module for Speech Construction is required to give software control of the speech module. With this Command Module in place, individual words may be accessed and spoken by typing the word on the keyboard. Access to the words may also be gained by using the CALL SAY statement in a BASIC program. Voice output is produced by the speaker contained in the TI 99/4 monitor.

Modem (Acoustic coupler)

The acoustic modem allows the TI 99/4 to communicate over telephone lines at a rate of 300-baud. It has orginate and answer modes, as well as a test capability. It is connected to the 99/4 through the RS-232 interface and a built in cable.

Remote Controls

These optional remote controls are used to position or move objects on the screen. Each unit includes eight-position remote control and a convenient side-mounted action button.

SOME APPLICATION EXAMPLES

Las Vegas slots

The Las Vegas Slots game makes use of the color graphics and sound capabilities of the TI 99/4 computer. Based on a typical slot machine, various fruit and other symbols are made to "spin" to give the illusion of motion. The shapes and colors are those of the customary machine. The program keeps track of the gains and loses of the player.

Organ

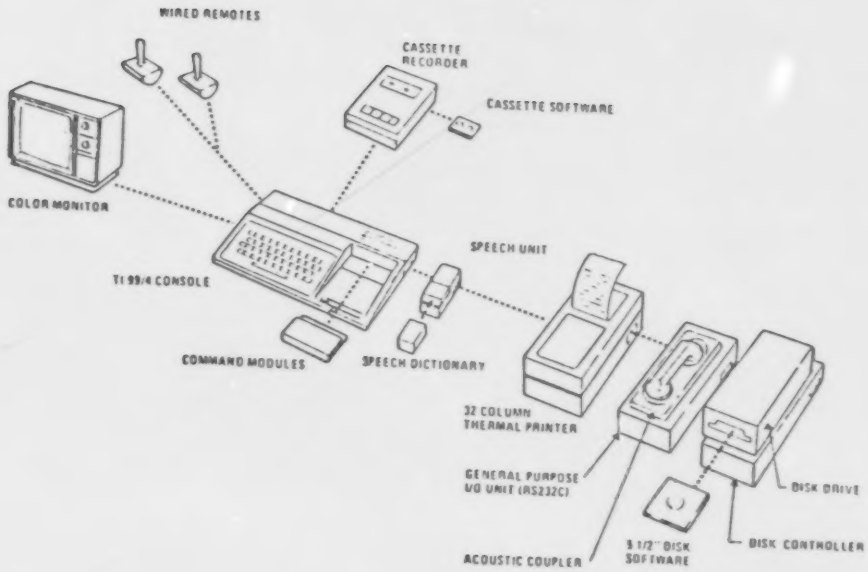
This program gives the effect of an electronic organ. The user can "play" the keyboard producing three note cords. Variations of the cord are also permitted. The music produced can be played through an amplifier system giving a full, rich rendition.

Tunnel

The Tunnel program gives the illusion of looking down a multi-colored tunnel. By manipulating the CALL COLOR statement the tunnel seems to become deeper and deeper with time. Bands of color alternate with the motion.

Expense statements

This program generates the proper calculations needed to fill out the typical expense statement report. Since usually these reports are quite wide, it is necessary for the program to have the screen scan the width of the report. All vertical columns are added and all horizontal lines are calculated. These are sumed as appropriate. All entries can be modified and corrected as needed. When connected to a printer, the TI 99/4 can produce a finished report.


WIRED REMOTES
CASSETTE RECORDER
CASSETTE SOFTWARE
COLOR MONITOR
TI 99/4 CONSOLE
SPEECH UNIT
COMMAND MODULES
SPEECH DICTIONARY
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CAI FOR THE DEVELOPMENTALLY HANDICAPPED:

NINE YEARS OF PROGRESS

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ABSTRACT

A nine year project is described in which CAI has been used at an institute for retarded young adults, most of whom also have associated physical handicaps. The teaching of social arithmetic and reading has necessitated the use of multi-media terminals. Several such terminals have been developed and used, and details are given for the present model, which is based upon a microprocessor. Principles used in the design of courseware are derived from research on learning among the retarded. Two program continua have been developed, aimed at enabling the trainees to acquire some of the social skills needed for independent living in the community. These continua are described together with their associated management systems. Special input devices enable the physically handicapped to communicate more easily with the computer; and "concept keyboards" assist the retarded by reducing the amount of mental recoding required. The success of the project is leading to further use of CAI, both at the present institute and at other centres for the retarded. Requirements for further development of CAI for the retarded are discussed.

1. CAI AT AN INSTITUTE FOR THE DEVELOPMENTALLY HANDICAPPED

It is now nine years since a CAI project was initiated by the University of Calgary Faculty of Education Computer Applications Unit for teaching developmentally handicapped young adults. Originally a research venture in cooperation with the Vocational and Rehabilitation Research Institute (VRRI) on the edge of the University campus, this project has now become an integral part of the education offered by the Institute. Further, it is being progressively extended within the VRRI and its success has led to the establishment of CAI in other centres for developmentally handicapped persons. These include a school for the retarded, a children's hospital school, an institute for the severely handicapped, and a centre for less severely handicapped young persons.

The VRRI provides education and vocational training for approximately 250 developmentally handicapped persons: that is, persons who have mental handicap and also, for the most part, some form of associated physical handicap. The trainees' ages range from 16 to 50 years, although most are between 18 and 24 years. The majority may be classified as "trainable", although a few are "educable" and a few "dependent". Some trainees have cerebral palsy, and some are severely disturbed.

The objective of the Institute is to give training in social and vocational skills to the point where trainees are able to support themselves and live independently in the community. Part of this training takes place in workshop units, and part in the Social Education Program; other units are concerned with pre-vocational training and assessment. All clients rotate through the Social Education Program, which accepts 170 of the trainees for approximately three month periods. Of this number, 100 are usually taking CAI lessons at any one time. For this purpose, seven multimedia terminals are in use on weekdays from 8.30 a.m. to 4.30 p.m., with each trainee having a half-hour session. The terminals are also used during certain

hours in the evenings and at the weekend.

2. SPECIAL REQUIREMENTS

The environment in an institute for the developmentally handicapped determines the kind of CAI that is required. The subject matter taught must have immediate relevance to the needs of the trainees. Some of them have already passed through the regular schools, without learning many number or language skills. Others come directly to the Institute through referrals from other institutions. If these people are to support themselves in the community, they need to learn "survival skills" such as money handling, shopping, budgeting and simple reading. Further, the teaching materials must not use content taken from elementary school texts designed to meet the interests of children: they must be specifically designed to be appropriate for an adult population.

It follows that, when such CAI programs are evaluated, an important factor to be taken into account is the amount of transfer from the program to a real life situation.

In regard to CAI terminals, the environment at an institute such as the VRRI implies that a simple hard-copy or display type terminal is not adequate. To teach money handling and shopping skills it is essential to have high quality image projection in order to illustrate coins, bills and items to be purchased. Most clients are unable to read and, although the use of simple and consistent routines can overcome many resulting problems, audio output is desirable. For learning to read it is obviously essential.

The conclusion is that CAI for the developmentally handicapped requires a terminal with multi-media output. For many trainees it is also more effective with a terminal which has special purpose input devices, while for those with severe physical handicaps such equipment is always required.

3. MULTI-MEDIA TERMINALS

The special requirements of CAI for the developmentally handicapped can not be met quickly and easily. They require a consistent effort over a period of years, with continuous evaluation and feedback aimed at improving the quality of both courseware and terminals.

The VRRI project began in 1971 with a single Teletype, using programs designed for elementary school level. None of the anticipated problems appeared. Those trainees chosen to participate initially had no difficulty in locating the keys on the keyboard: and there was no damage to equipment, nor has there been during all the nine years of the project. An unexpected bonus was the high level of interest and motivation shown. Results were considerably better than expected, but it was apparent that many improvements could be made.

The Computer Applications Unit has always used a computer dedicated to CAI, with commercially available time-shared software. Initially this was a DEC TSS-8 system, with 17 ports, but this was replaced in 1976 by a DEC PDP 11/70 system with 48 ports. Connection to such ports from the VRRI and other remote centres is via the ordinary telephone network. Therefore the use of several peripherals, attached to a standard hard-copy or display terminal to make it into a multi-media terminal, requires an interface between these devices and the modem.

The Unit developed an interface to control a Kodak random access carousel slide projector in 1969. Four such multi-media CAI terminals were installed in a trailer, which was located at the VRRI. The first money handling and shopping programs were used in this trailer with considerable success (Strain, 1974). When an extension to the VRRI building was completed in early 1976, the four multi-media terminals were therefore moved into a special CAI room and more terminals were installed. Not only was this much more convenient for use, it was now possible to use CAI for teaching the cerebral palsied trainees confined to wheelchairs, and others who were unable to climb the few steps into the trailer.

A prototype terminal developed by the National Research Council of Canada was introduced. This was a more complex multi-media terminal and had an interface which controlled, besides the hard-copy or display terminal, a slide projector, a tape recorder for audio output, and an ultra-sonic touch sensitive display for input (Hlady, 1969). The latter proved to be a very effective and versatile input device.

Later, a commercial version of this multi-media terminal was also in operation for the reading programs. This had a cassette device for audio output, and a touch sensitive display using light emitting diodes and photosensitive transistors.

At the present time, almost all the CAI for the developmentally handicapped makes use of a microprocessor-based multi-media terminal developed in the Computer Applications Unit in 1978. Fifteen such terminals have been constructed. Each uses an 8080 chip, which has proven reliability, and an S-100 bus to provide flexibility. Depending upon the applications for which it is used, the terminal may have up to 56K bytes of RAM and 16K bytes of EPROM. The latter is used for storage of utility programs, and sometimes for synthetic speech data. The character generator provides 24 lines of 80 characters as standard, but can also give 12 lines of 40 double size characters. Prior to the introduction of these terminals it had been necessary to use a 23 inch monitor for work with the cerebral palsied, many of whom are partially sighted. It is now possible to use the large size characters on the 17 inch monitor which is a standard component of the terminal. A graphics board allows control of 240 x 256 points on the screen. A Computalker board is used to produce a limited amount of synthetic speech; and a board has been developed to control the Kodak random access carousel slide projector. This last board also has a jump-on-restart facility, so that it is not necessary for the microcomputer to have a front panel: it is activated as a terminal when the power is switched on.

The microcomputer and slide projector are housed in a comparatively small box, the front of which forms a rearview screen. The monitor is placed in line with the screen, and the keyboard is placed in front. Special purpose input devices can be attached to the keyboard.

Using the maximum amount of RAM, and one or two floppy disks, the terminal becomes a stand-alone CAI computer capable of supporting all the programs in use for the developmentally handicapped. In this configuration, one terminal has been placed in a small town 80 miles from Calgary and has been used successfully in a project for the handicapped since August 1979.

4. DESIGN OF COURSEWARE

The most important sets of social survival skills needed by developmentally handicapped persons, when they have to support themselves in the community, relate first to money handling and secondly to reading. The curricula used to teach these two sets of skills at VRRI were therefore divided into units, each representing one subskill. These were then arranged in a linear and progressive sequence to form two continua, one for social arithmetic and one for reading. Within each continuum, a CAI program was developed for each unit which taught that subskill and tested it to criterion before the trainee was allowed to proceed to the next unit. The purpose was to form a carefully structured curriculum, divided into small learning steps arranged in a hierarchy and leading to the required survival skills.

The continuum of social arithmetic programs makes use of the microprocessor-based terminal. It begins with counting skills, and proceeds to simple addition, subtraction, and place value. This is followed by units on the recognition of coins and bills, more complex addition and subtraction, and problems relating to money. Later units are concerned with shopping and making change, keeping bank accounts, and budgeting. The eighty units are controlled by a management system which monitors each trainee's progress. A high passing criterion is set to ensure repetition of the units and thus achieve over-learning. The system allows the instructor to obtain reports on all trainees or on an individual trainee. If necessary, the instructor can override the management system to place a trainee at a more appropriate skill level.

The reading continuum makes use of both the microprocessor-based terminal and a commercial terminal referred to earlier. The first part of the continuum is concerned with recognition of shapes and letters. The second part consists of forty units, specially written to teach reading to young adults (Brown and Bookbinder, 1967). The earlier units are concerned with recognition and pronunciation of phonemes; these are then embedded in words; and in the later units sentences and paragraphs are introduced. All units make use of cassette-based audio under computer control, and each is followed by a test for which answers are entered using a touch sensitive display. They are arranged in a linear sequence but a management system routes a trainee to go forward three units, then drop back two. This ensures constant rehearsal of the skills which are learned.

The third part of the reading continuum consists of social sight vocabulary programs which are used to teach recognition of common words such as "Telephone" and "Poison". Again, this requires use of a slide projector and,

preferably, a small amount of audio (Holz, 1976).

Various programs for the developmentally handicapped are used to teach skills other than money handling and reading which are needed for daily living. These include programs to teach nutrition, time sense, laundry symbols, and filling in of forms, also a program to train cafeteria cashiers. The latter is the first of what is intended to be a set of programs relating to vocational skills.

Throughout the programs, didactic procedures are avoided and verbal instructions, either written or oral, are kept to a minimum. Insofar as possible, behaviour is "shaped" as one CAI program follows another.

Two important characteristics of the developmentally handicapped are a limited short term memory and an inability to attend to relevant cues. The programs are therefore designed to give frequent and immediate reinforcement in relatively consistent formats which can be easily recognized by the trainees, and repetition is used to achieve overlearning. When material for a new skill is presented, irrelevant stimuli are deleted. Following successful practice of the skill, a wide range of stimuli are shown in order to facilitate generalization to a real life situation. For example, when teaching the words "No Trespassing", a slide is first presented which shows only these two words. When they have been mastered, other slides present the words in context, on a sign standing in a field.

Provided that the continua contain carefully sequenced programs which ensure success and the teaching materials relate to adult interests, motivation of developmentally handicapped persons taking CAI programs is not a problem. Indeed, all the evidence indicates that attention span increases substantially when they use a computer terminal: trainees at the VRRI enjoy their CAI sessions.

5. SPECIAL INPUT DEVICES

Special input devices have been developed in the Computer Applications Unit in order to enable more handicapped persons to access the CAI programs, and also to make such programs more effective. The special devices may therefore be classified into two types: those which allow a trainee to overcome a physical handicap, and those which simplify the mental operations required to interact with the program.

Devices of the former type have frequently been developed for use by the cerebral palsied trainees at the VRRI. A computer terminal interface for POSSUM apparatus was produced several years ago and has been described elsewhere (Hallworth and Brebner, 1979). This consists of an indicator board on which a light may be moved using any binary control such as a handswitch or a footswitch, or a mouthpiece on which the user can suck and puff. When the light has been positioned in the square of the required character, this is entered into the computer using the same control apparatus. A POSSUM Expanded Keyboard may be used by trainees who do not have the strength or motor precision to operate a standard keyboard. Mention has already been made of two touch sensitive displays which have proved to be very effective input devices. The microprocessor-based terminal incorporates an inexpensive light pen which appears potentially useful to some handicapped persons.

In effect, there has so far been only one VRRI trainee who was unable to use a CAI terminal due to physical handicap, and he suffered from multiple handicaps including extremely poor vision.

The special input devices intended to simplify the mental operations required to interact with the CAI programs all perform essentially the same function: they reduce the amount of recoding required by the user.

The touch sensitive displays achieve this by allowing the handicapped person to point, with his finger or a a stylus, at an image projected on to the screen or a word displayed on the CRT. In either case, there is no necessity to recode the image or word into the symbols shown on the standard keyboard. With persons who have a limited short term memory, this can be a decided advantage.

Special purpose keyboards which can be attached to the microprocessor terminal achieve the same effect by presenting to the handicapped person the images or codes which are required to be learned. For example, a "money keyboard" is used with some of the social arithmetic programs on which the keys are actual bills and coins: no other keys are included except RETURN and DELETE. For the program to teach laundry symbols, a keyboard is used on which the keys are the symbols to be learned, again with only RETURN and DELETE, in addition. For use with the program to teach a sense of time there

is a keyboard with three keys only, representing "Early", "On Time", and "Late"; and for use with the nutrition program, a special keyboard has keys with illustrations of the major food groups. For the program to train handicapped persons as cafeteria cashiers, a cash register has been converted into a computer terminal by using pieces of bubble-pad keyboard in place of the usual keys. Similar material may be used to teach Bliss symbols.

It is a difficult task for a handicapped person to recode stimuli into numbers or letters, and perform further mental operations on such symbols before taking overt action to answer the question in a CAI program. When the objective is to teach social arithmetic skills such recoding may be quite unnecessary, and may indeed inhibit the required learning. Special purpose keyboards, sometimes referred to as "concept" keyboards, can alleviate this problem.

6. RESULTS

Numerous studies relating to different CAI programs used with developmentally handicapped persons have already demonstrated that they are effective (e.g. Sandals, 1973; Strain, 1974; Eaton, 1975; Holz, 1976; England, 1979). Moreover, it should be noted that most of these studies have used a "transfer test", to ensure that the skills learned are not merely related to material presented through a CAI terminal, but are transferable to real life situations. Direct observation of individual trainees has indicated that there are sometimes dramatic improvements in rate of learning. The unanticipated benefit of increased attention span has already been mentioned. There is also an improved attitude to other types of learning.

For these reasons, CAI has become an integral part of the Social Education Program at the VRRI. It is gradually extending into other units at the Institute, and into other institutions for the handicapped, Further, with the progressive reduction in hardware costs, CAI is already so much less expensive than traditional instruction that it is easily justified as a tool for teachers of the handicapped.

It is only too apparent, however, that much work remains to be done. There is an urgent need for better quality and more reliable audio, therefore work is in progress in the Computer Applications Unit on the use of digitized speech. With the advent of low cost eight-inch Winchester disks, this may soon be economically feasible. Hopefully, in the near future the use of videodiscs will lead to more effective audio and video, and also allow much needed movie sequences.

The major problem will therefore lie in the area of courseware. If present experience is any guide, a considerable amount of research and development work will be required over a period of many years before we have available, for developmentally handicapped persons, CAI programs which are as effective as we believe they should be.

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PROCEDURAL GUIDES FOR IMPLEMENTATION OF ISD

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ABSTRACT

This paper describes a series of 13 Job Aids, developed by HumRRO, as procedural guides for implementing the first three phases of the Instructional Systems Development (ISD) model. Each Job Aid consists of two documents: a Job Aid Manual, which provides specific guidance examples, and references for the activity covered; and a Descriptive Authoring Flowchart, which constitutes a key to the material in the Manual. One of the Job Aids (Job Aid for Selecting Instructional Setting) is described in some detail, as an example. Its objective, the steps it employs in accomplishing that objective, the resulting product, and a worksheet that documents the decisions of the Job Aid user are all discussed briefly. The general format presented here characterizes the 13 existing Job Aids and five others (corresponding to phases four and five of the model) that are under development.

During the past 20 years, many attempts have been made to codify a definitive technology for the systems approach to training. Early efforts in this area include those by the Human Resources Research Organization (HumRRO) on behalf of the U.S. Army in the early 1950's and the development of the USAF personnel subsystem approach in the mid-1950's.

One of the more notable of recent systems approach efforts is the Interservice Procedures for Instructional Systems Development Model (TRADOC Pamphlet No. 350-30 (1,2,3,4,5). This model was prepared by the Center for Education Technology at Florida State University under contract with the Interservice Committee for Instructional Systems and Development, involving the Navy, Air Force, Marine Corps, and the Army. The model (ISD) contains standardized rationale, terminology, and basic concepts of instructional systems.

The ISD model is advanced over other systems approach models in providing guidance to the training manager. However, the ISD manuals are not presently intended to provide specific procedures for every instructional situation that can be encountered. Some situations are now covered only by the general principles underlying the model.

To provide the specific guidance needed ("how to do it") for implementing the ISD model, the Eastern Division of HumRRO has developed a series of Job Aids. These Job Aids assist Army instructional development personnel in the analysis, design, and development of instructional materials.[1] The job aids are intended to be stand-alone, step-by-step procedural guides which are equally useful to individuals at all experience levels of the instructional systems development process.

The Job Aids are also intended to address real needs. Prior to the development of the Job Aids, instructional technology personnel at the U.S. Army Signal Center, Fort Gordon, Georgia, and the U.S. Army Engineer School, Fort Belvoir,

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[1]The HumRRO Job Aids were developed in a HumRRO Project for the U.S. Army Research Institute for the Behavioral and Social Sciences and the Defense Advanced Research Projects Agency under contract DAHC19-78-0010.

Virginia, were surveyed to determine specific ISD needs--those areas in which they had the greatest need for assistance and information. Emphasis was placed on satisfying these needs in the development of the HumRRO Job Aids.

HumRRO Job Aids use the same classification system for identifying the activities that must be performed in instructional systems development as does TRADOC Pamphlet 350-30 (1,2,3,4,5). However, the Job Aids are not just a re-hash of the TRADOC Pamphlet. We use the same classification system but the guidance and information provided in the Job Aids come from a variety of sources, the TRADOC Pamphlet being only one such source. In some instances, the information in the Job Aid is based solely on the educational technology experience of the HumRRO staff.

HumRRO Job Aids cover the activities required for the first three phases of the TRADOC Pamphlet (i.e., Analyze, Design, and Develop Instructional Systems). The Aids cover each ISD block within these phases except for ISD Block I.1, Analyze Job. There are 13 Job Aids available. They are:

- Job Aid for Selecting Tasks for Training
- Job Aid for Conducting Task Analysis
- Job Aid for Analyzing Existing Courses
- Job Aid for Selecting Instructional Setting
- Job Aid for Developing Objectives
- Job Aid for Developing Tests
- Job Aid for Describing Entry Behavior
- Job Aid for Determining Sequence and Structure
- Job Aid for Specifying Learning Events and Activities
- Job Aid for Specifying Instructional Management Plan and Delivery System
- Job Aid for Review and Selection of Existing Materials
- Job Aid for Developing Instruction
- Job Aid for Validating Instruction

DESCRIPTIVE AUTHORING FLOWCHARTS

The Descriptive Authoring Flowcharts are the primary documents used in the HumRRO Job Aids. They direct the user to specific guidance, examples and references provided in the Job Aid Manuals.

JOB AID MANUALS

As stated above, the Job Aid Manuals provide the specific guidance, examples and references necessary to produce the product for the instructional systems development activity they cover. In addition, each Job Aid Manual contains one or more worksheets to use in the development of the product.

U.S. Army Signal School and U.S. Army Engineer School instructional technologists, as users of the Job Aids, were the source of evaluation data. The major evaluation thus far has been a comprehensive formative evaluation.

Formative evaluation data were gathered by monitoring Signal and Engineer School personnel as they went through their analytic, design, and development activities in the process of producing instructional material. First, data were collected (as a baseline) from these personnel as they performed their ISD functions without the assistance of the HumRRO Job Aids. Each Job Aid was then provided to a minimum of five individuals who were currently engaged in the activity covered by the aid. Data relating to time required to produce the called-for products, quality of the product produced, problems encountered in using the Job Aid, and user acceptance of the aid were collected from each of these individuals. The data have not yet been completely analyzed. However, comparisons will be made with the baseline data to assess any gains in performance which can be attributed to the use of the Job Aids.

Thus, we presently have the data for comparing the performance and attitudes of U.S. Army Signal and Engineer School personnel before the aids were introduced, and during their use. Early indications strongly support the usefulness of our Job Aids. However, additional tryouts will be necessary before final judgments can be reached as to their overall effectiveness.

To be maximally effective, the Job Aids should be used in the continuous ISD process. That is, output from the first Job Aid feeds into the second, which feeds into the third, etc. Time constraints prevented such a longitudinal implementation and evaluation. This should be done. Support is currently being sought to perform such a validation study.

In addition to the 13 Job Aids already developed, HumRRO has underway two other related efforts. The first is to develop and evaluate a prototype system-independent Programming Design Guide for one of the 13 Job Aids already developed. The Programming Design Guide is a manual which describes the procedural activities in the aid in sufficient detail to permit their installation on a computer-based instructional system. An important part of this effort is that the Programming

Design Guide is developed so that it is computer system independent.

The second effort underway is the development of Job Aids for the final two phases of the ISD model. These phases deal with the implementation (Phase IV) and control (Phase V) of instruction. The specific aids to be developed are:

- Job Aid for the Implementation of the Instructional Management Plan
- Job Aid for Conducting Instruction
- Job Aid for Conducting Internal Evaluation
- Job Aid for Conducting External Evaluation
- Job Aid for Revising the System

Space does not permit the detailed descriptions of the two ongoing efforts. Suffice it to say that the Programming Design Guide is intended to permit the Job Aid to be available to users in an inquiry-type, on-line computer version. Also, the Job Aids developed for Phases IV and V of the ISD model will use the same format as in the first 13 Job Aids.

To give the reader a better understanding of the Job Aids, the remainder of this paper will describe, in limited detail, one Job Aid--Job Aid for Selecting Instructional Setting.

The purpose of the Job Aid for Selecting Instructional Setting is to help choose instructional settings (training locations for tasks selected (in ISD I.2, Select Tasks/Functions) for training. Three major settings (or locations) are currently in use in the Army. They are: institution (training conducted at resident schools), supervised on-the-job training (SOJT)--training conducted at the soldier's unit, and self-study (training administered during individual's own time, usually at the soldier's unit).

The Job Aid employs four major steps in selecting the instructional setting for each task. The four steps are shown in Table 1. A brief description of each step follows:

Step 1. Tasks selected for training are listed and categorized by skill level[2] and duty position[3] on an Instructional Setting Recording (ISR) sheet. The ISR sheet is the worksheet used in the Job Aid for documenting the decisions made by the Job Aid user.

[2]Within any Military Occupational Specialty (MOS) there are five skill levels which identify the MOS holder's level of expertise within the MOS.

[3]Duty position is a specific job that the MOS holder has within the MOS.

Step 2. Task performance data are obtained and recorded on the ISR sheet for each task. The specific performance data recorded are:

1. In which duty position is the task performed, and
2. what percentage of soldiers perform the task?

The Job Aid provides potential sources for obtaining information necessary for answering the above questions. (Potential sources of information are provided throughout the job aid whenever the user must answer a question or make a decision.)

Table 1. Four Major Steps in Selecting Instructional Setting

Step 1.	Tasks for training are listed and categorized by skill level and duty position.
Step 2.	Task performance data are obtained and recorded for each task. That is: a) In which duty position is the task performed? b) What percentage of soldiers perform the task?
Step 3.	Initial assignment of the task to one of three instructional settings (institution, supervised on-the-job training, or self-study) is made based on the answers to as many as 14 questions.
Step 4.	Administrative review and final selection of instructional setting.

Step 3. Initial assignment of the task to one of the three instructional settings (institution, supervised on-the-job training, or self-study) is made based on the answers to the fourteen questions shown in Table 2. It should be noted that for the majority of tasks. not all questions will need to be asked before a decision is reached as to the initial instructional setting assignment. The algorithm used in asking the questions shown in Table 2 is as follows (please refer to the table).

Table 2. Questions Used for Selecting Instructional Setting

INSTITUTION	
1)	Common skill level task?
2)	High performance task?
3)	Training requirements highly similar?
4)	High task retention?
5)	High theory content?
6)	Need for immediate performance?
7)	Prerequisite for task selected for school?
8)	Equipment/facilities unique to school?
SOJT	
9)	Equipment available at unit?
10)	Supervision available at unit?
11)	Time to traing available at unit?
SELF-STUDY	
12)	Little supervision required?
13)	Time to study available?
14)	Lessons/equipment exportable?

- If the answer to question 1 or 2 is "yes," questions 3 and 4 are asked. If "no," questions 5 through 9 are asked next.
- When questions 3 and 4 are asked, if both questions are answered "yes," the task is initially assigned to the institutional instructional setting. No further questions are asked. If either question 3 or 4 is answered "no," questions 5 through 8 are asked.
- If one or more "yes" responses are given to questions 5 through 8, the task is initially assigned to the institutional instructional setting. If all "no" responses were given, questions 9 through 11 are asked.
- If all questions (9 through 11) are asnwered "yes," the task is initially assigned to supervised on-the-job training instructional setting. If one or more "no" answers, questions 12 through 14 are asked.
- If all questions (12 through 14) are answered "yes," the task is initially assigned to self-study instructional setting. If one or more "no" responses, questions 9 through 14 are re-evaluated to determine if an instructional setting can be selected without assistance for the Job Aid user's supervisor.

Step 4. Administrative and final selection of instructional setting. In Step 3, tasks were assigned initially to one of the three instructional settings. In this step, each task is reviewed to determine if the initial assignment is still the best instructional setting on the basis of expert opinion. If changes in instructional setting are made, the rationale for each change is documented on the ISR sheet. The completed ISR sheet is submitted to the Job Aid user's supervisor for review and approval.

In summary, the product that results for the Job Aid for Selecting Instructional Setting is a listing of all critical tasks in which each task is assigned for training to one of the following instructional settings:

- Institution (resident school training)
- Supervised On-the-Job Training (SOJT)
- Self-study

While only one Job Aid has been described in this paper, the other Job Aids follow the same type of format and each employs a worksheet for making and documenting decisions.

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GRAPHIC DESIGN AND COMPUTER-BASED LEARNING

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ABSTRACT

An important, but usually neglected, component of good computer-based learning material is that of screen design, the visual and temporal structure of text and graphics on the computer display. Much, perhaps even most, existing material is very poorly designed. The tendency is to treat the screen as a page of a book, but many profound differences exist. A critical person for achieving well-designed material is a good graphic artist.

Consider the following two situations. The first is the preparation of an ad in a national magazine, perhaps by a major computer company. After the company makes the decision to run the ad and decisions on content, graphic designers carry out the task of preparing the ad. Although designers can be hired at various salaries, a major company will use the best industrial and graphic designers. Thus, a company such as IBM has worked with internationally famous designers such as Charles and Ray Eames and Elliot Noyes for exhibits, ads, and product design. The company realizes that the message they are portraying in the ad is much more likely to be effective with its audience if the skills of very competent designers are used. Hence, the additional expense is felt to be warranted.

This situation should be contrasted with the typical preparation of learning materials in a wide variety of forms and media. It only takes a few glances at the average textbook in almost any area, for example, to note that design issues are often ignored; bulletin boards in universities also show that design considerations play little if any role. Although there have been a few excellently done films and videotapes, that is not the typical situation. Many faculty members feel that the use of well-designed products is only a gloss, not justified by cost.

I argue in this paper that design does play an important role in learning, a role that we do not fully understand. I wish also to consider how design can be brought into an effective system for producing computer-based learning material, with emphasis on large-scale future production.

VISUAL INFORMATION AND LEARNING

Although faculty members often take a scornful view toward design, for thousands of years teachers have understood that visual information is important in the learning process at least for some students. It is almost a truism that different students learn in different styles. For some iconic information can be very important, perhaps even more important than verbal information. Alternate modes of presentation are often useful, allowing students to work in different ways. For a summary of the literature, see Iconic Communication, W. H. Huggins and Doris R. Entwisle (Johns Hopkins Press, 1974).

Recently a new and exciting line of research has added reasssurance to our intuitive beliefs that pictorial ways of learning are important. The research referred to is the recent efforts concerning the split brain. While there is still much to be learned, work so far indicates that in a normal right-handed person the left brain performs analytic and verbal functions while the right brain is more concerned with patterns and holistic information. While this is a simpli-

fication, the indication is that if learning is to use the full brain, both sides, then both verbal and pictorial information is important.

Education has long been highly verbal, but we began visually. Humans were, we suspect, much better visual learners in the early stages of civilization or even in early life than the mature individual is today. Little else was or is possible at these stages.

Today's teachers are the successful products of a verbally oriented educational system. But many of the students in the same classes with these teachers suffered because they were not so linguistically acute. As we press ourselves to use visual information we can achieve the goals of learning for a wider and wider range of students.

Visual literacy is not a concern of only the teacher. Perhaps the most important resource in visual literacy are the people who are particularly concerned with it, the artists and designers. It is from these sources that we can hope to learn to improve our educational materials.

READABILITY AND TEXT DESIGN

So far our discussion has referred only to explicitly pictorial information. But visual design goes further than this. I claim that text itself, rightly considered, is a graphic element. An artist doing layout for an ad realizes that the overall design involves both pictorial and textual components.

Consider a screen on a TV-like display, such as that used for computer-based learning. The student at any one time typically sees a combination of graphic and alphanumeric information. It is the composition as a whole, the combination of the two components, pictorial and alphanumeric, that is important, not the individual components. Developers of computer-based learning material with considerable experience with other media tend to rely on those experiences. Looking at many examples, it is obvious that the screen is often viewed as simply a page of a book. Frames in computer-based learning programs look very much like pages of a book, with dense text all starting at the left-hand side of the screen.

The screen is not a page in a book. Spatial and temporal considerations are very different on a page in a book and on the screen of a display. When the student turns the page of a book everything is visible on the new page. But the material on the screen can appear dynamically, but not necessarily in a linear order. Furthermore, the book offers no timing considerations. Everything is there at once. But elements on a screen can be put on one by one in any order with suitable displays between. Text can appear at a controlled rate, even controllable by the student.

Furthermore, financial considerations for screen and book are very different. Consider the issue of blank space. In books blank space is a rare commodity. Although good designers always argue for its use, each bit of blank space is likely to increase the overall cost of the book. The production costs of a book go up as the number of pages increase. So the editor resists using much blank space. But the situation is very different on the screen. Blank space can be used freely in any way that will enhance the learning experience; its cost is effectively zero.

As one aspect of the unanswered questions surrounding text design, consider readability of material on the screen; this is not the only issue, but it demands attention. Students today are often not good readers. But there is very little usable research on screen readability. The best compilations of print readability for practical purposes have been work at The Open University.

The issue of blank space just mentioned is typical of the factors that appear to affect accurate reading. The student confronted with a whole page of dense material may go into a sloppy mode of reading. Quick scanning of a page is often encouraged in our society. However, a student presented with only a few sentences on the screen at one time is in a very different situation and is, we speculate, more likely to read the material carefully.

Other factors affect readability. Standard techniques common to books, and in particular textbooks, have a negative effect on readability. For example, hyphenation increases reading errors. Justification of left and right margins also typically increases errors. It is difficult to find a printed text, except for those coming from such places as art museums and first-rate designers, that does not use these two features. Indeed, with text processing systems, a very crude form of justification at the whole space level (only whole spaces used to fill out the line) has unfortunately become common in spite of the ugly appearance of such material and its negative effect on readability.

A number of other factors influence reading of print material and may affect

screen reading. Short lines, and therefore less eye movement in reading a line, is one such factor. Readability is aided by the use of natural phrases on a line, not breaking the line at an arbitrary point. (Some books have even been written in what looks almost like poetry!)

Timing considerations available on a film but not a book can also be very important. The computer can stop after sentences and before and after critical words and phrases. Again, our intuition suggests that timing can aid comprehension.

Most of these considerations of readability are based on work with printed material. It is still to be determined whether they apply to the screen. Further research in this area is needed.

PRODUCTION PROCESS AND DESIGN

The question that confronts us is how computer-based learning materials can make use of design, employing visual and textual design elements to enhance student learning. Often design has either been ignored or has been a minor consideration in developing computer dialogs. This is a serious error, particularly as we look toward the possibilities of widespread use of computer-based learning material.

First, we need more research. Our ideas about screen readability and visual learning need further work. But, more immediately, we must learn how to use the insights of excellent graphic designers in the production process. The large companies mentioned earlier do not have research support for the way they develop ads, but they still use very good designers. How can we use these good artists in generating computer-based learning material?

Where within the production process is design to occur? The notion of a production process for this area is still a relatively new one. In the early days individuals worked in a cottage industry process, with each individual responsible for the full range of activities. Recently, looking toward the future, there has been important experimentation with production systems for efficient and effective development. The skills of good teachers and instructional designers are needed in the pedagogical stage, and the skills of programmers are needed in preparing the program. Neither, however, is likely to be successful in the visual design process. Few teachers, and even fewer programmers, have full understanding of design. The graphic design activities should be placed between the pedagogical design and the actual programming.

The next issue concerns who will be involved in the design activities. A skilled designer is needed. The type of person who does magazine layout is a good possibility. But the designer should be particularly attuned to educational possibilities of design and must be willing to work in a very different medium than print or film. The pictorial information that is possible is at a much cruder level than that currently used in books and magazines. While a good graphic designer (not afraid of computers) would be the likely choice, some special education, such as issues concerning readability, is important.

Careful consideration must be given to the environment in which the designer is to work in aiding with the production process. The environment must be natural for those involved, the designers. The screen of the delivery system is the natural medium to work on for design. One cannot work on paper or with other graphic modes, because many of the elements are different from the elements of the screen. So the designer should be working directly at the display.

Design is an interactive process with much experimentation. At least three kinds of activities seem critical for the designer in constructing the screen. The first is that he or she must be able to create objects, both visual and graphic objects. Hence, a range of facilities should allow the creation of full pictorial information and creation of any type of textual information. For example, in text such abilities as right justification and centering, used frequently in good print design, should be possible. The ability to define areas of the screen to be certain that the text fits in those areas is an important consideration, as what happens on the screen in a highly interactive program can only be determined when the module is used by students.

The second control the designer requires in any design activity is the ability to modify the objects just developed. It may be that they are too large or that their aspect ratio needs to be changed. Finally, the designer needs to move objects around the screen in easy ways, so as to create the arrangement that seems most effective.

The designer's work must be available to the programmer. The two best possibilities are that the computer itself, on command by the designer, will either prepare computer code or write the necessary information to files. In both cases adequate documentation can also be provided by the computer itself.

IMPLEMENTATIONS

At Irvine we have developed two graphic design environments for computer-based learning following the ideas presented above--one APL based and the other Pascal based. When we first embarked on this we did not have a clear vision of what we were doing. So we have had to learn by experience.

The initial version of the APL system was developed as a picture creator, an easy way to get the computer to prepare computer code for pictures. But as we began to gain experience with this system, we understood that the development of these pictures was only part of the total design process.

APL was chosen for our first system because it is an interactive language with good graphic capabilities. Furthermore, its array structure promised some savings, since graphic data is often array data. Availability of a good APL system was also a factor.

In our newly designed system we are using Pascal as a base language, as we are with our other developments in moving our learning materials to the personal computer environment. Pascal is a recent structured language, following what is now known about good programming. Other papers available describe our new approach in more detail.

So far the primary system that we have been working on is the Terak 8510/a; we are beginning to use the Apple II as a delivery system. We are incorporating many new capabilities within the Pascal program, but it is still too early to say whether these will all be of benefit to the graphic designer.

It must be admitted that much more experience is needed in this area before it will be possible to understand fully whether all these features are effective for graphic designers. As relatively few designers have used such systems, much more experimentation and experience is needed before we can be reasonably certain that we understand the situation.

Standards For The Development of Drill and Practice on Microcomputers

"MELBORP"

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Standards for the design and coding of microcomputer software must be developed.

The presumption being that standards should exist has come from a frustration at seeing sloppy, incomplete, and error ridden microcomputer programs. Too many programs being advertised as "instructional" fail to even consider basic educational objectives.

A couple of the most prevalent and unforgivable drill and practice error conditions are the 'stop I want to get off loop' and the 'unpredictable bomb'.

The first condition occurs when the learner is presented with a problem that either is too difficult or has not been dealt with before. The learner enters an incorrect response which is then responded to by the software and the same problem is again displayed. This cycle is then repeated until in a fit of frustration the learner leaves or smashes the keyboard.

The unpredictable bomb condition is simply the reoccuring instance where, by either mistake or intent, a problem response is entered by the learner that has not been anticipated. As a result, the problem blows up and the learner finds himself outside the program control, or 'up the creek without an input'.

Until standards for educational courseware become written, discussed, and further refined, we will continue to see the incomplete micro-software which is now available almost everywhere. It is with this intent that the following project was designed for, and is now under development at the Regional Computing Center for the Board of Cooperative Educational Services in Spencerport, New York.

Drill and Practice was the mode of instruction selected for the development project using the microcomputer. This part of C.A.I. was selected because it was and is the author's feeling that the strongest single argument for using computers as a teacher tool is to permit the teacher to become more effective. The tedium of drill and practice is an ideal function of the computer-tool especially when properly designed and implemented.

The following were initial goals established for development of a Drill and Practice System using microcomputers:

1. To provide a fun way to learn. If kids are enjoying the experience, motivation tends to be high. When simulations and games are used to reinforce the learning of key concepts and skills, students stop at nothing --even serious study, to be at the machine. (1)

With these thoughts overriding the development of the system, it was felt that the system should attempt to utilize as many of the current capabilities of microprocessors as appropriate--both educationally and economically. Educationally appropriate refers to the motivational capabilities of the hardware; regarding color, graphics, and sound. The system should be economically feasible in terms of price, user acceptance and language compatability.

2. To allow both competitive and non-competitive modes of interaction. One of these modes of interaction would be selected by the learner.

(1)Thomas Dwyer, "Some Thoughts on Computers and Greatness in Teaching" Topics in Instructional Computing, Vol. 1, ACM special interest group on computer uses in education, 1975.

a. Practice--self drill
b. Competitive--two players or two teams
c. Competitive--one player/team versus the computer

In our initial experiences we found the third method of competition, against the computer, to be potentially defeating. This called for modifications to slow down the computer's response to a problem (let the computer think for a second). It also became important for the computer when competing to be more humanlike (it always knew the right answer). The system was given a variable to set the percentage of right answers for the computer. After much discussion, it was felt that an achievement level of 80 percent to 90 percent was realistic for most competition.

3. Problem types would be linked to curriculum objectives. For the teachers to use the system most effectively, it should be linked as closely as possible to the current curriculum objectives. For example, the teacher (and maybe the learner, too) should have control over the scope and emphasis of the problems used in the competition.
4. To develop standards for the design of the proposed system. Variables will have somewhat logical names and may be reserved for specified operations and/or functions. The system will be structured by logical functions thus leading to the development of structured modules.

The intent will be for graphics modules to be developed separately and linked later by a management routine with the proper instructional data bases. Instructional data modules will likewise be independent of any graphics or game displays.

5. A management routine will be designed and implemented to: (a) handle all record keeping tasks; (b) provide teacher assistance through reports and decision making algorithms; and (c) establish necessary linking of game themes with instructional drill data.
6. To utilize appropriate technical and non-technical personnel (within budget constrictions) in all development phases. For example: A computer/art student was employed to coordinate uses of color, space, animation, and sound; a teacher was used in the development of curriculum objectives; and, a computer/engineering student was utilized to design and code machine level routines for speed in graphics and necessary program/file linkages.

Since there would be three major sections for independent development--namely Graphics, Curriculum Based Problem Solving, and Management, the next segment deals with the derived functions of each. Since this was an exploratory type project, the standards were allowed to be modified somewhat as development grew.

Functions:

A. The Management Section was responsible for providing the teacher with basic utilities for class/student management as well as for the overall system operation. The following student data parameters would be accessed by the teacher using the manager.
   --name
   --number
   --graphics module limitations
   --time limits on problems/on games
   --history data
     --date/time using the system
     --problem type
     --performance/score

   The student control procedure would be controlled by the manager as follows:
   1. request name and number
   2. verify enrollment--obtain history data and limitations parameters
   3. give student option (if any) for problem type and graphics action
   4. link problem solving sections with proper graphics routines
   5. pass control to problem solving to generate problems
   6. record student statistics when done

B. The Problem Solving Section generates the correct problem from the type or range specified by the teacher. It prints the problem in the proper area specified by the graphics routine. The correct answers for the problems are then calculated and checked with the response returned by the learner. If an illegal answer is returned (ex: letter instead of number) an appropriate response is displayed.

   The problem routine is designed to select from a wide range of number or word problems and to accept and parse any reply.

C. The Graphics Section is in complete control of the screen and sound. The graphics module initially displays the title or opening frame followed by whatever instructions might be necessary for interaction.

   The environment for play and/or

competition is established in this section using background and foreground colors, blinking or scrolling sections, and whatever other objects or scenery might be required.

This section also handles whatever screen action takes place when a correct answer is entered by the learner. Since action is usually only initiated by a correct answer, an incorrect response will display only the correct answer. Once a win situation is encountered, the graphics section may provide an appropriate animation or display routine.

Summary

Through the course of putting this system together, a number of concerns have been discussed and incorporated into the standards regarding the use of microcomputers for drill and practice.

A floppy disk or other direct access storage device is essential. Cassette tape units are too slow and do not provide the capabilities required for rapid linking and data base interactions.

Since the project was attempting to focus on problem solving in a drill and practice mode, the emphasis was determined to be placed on presenting the next problem rather than spending time constructing or performing time-consuming graphics. As a general rule, an attempt was made to limit all correct answer graphics action to less than five seconds. By utilizing a person with art background it was possible to use space effectively rather than attempt to fill the screen with shapes and colors.

Animation and sound were incorporated, but only where appropriate and also only when time was available.

It was the goal to design and program all modules and routines using top down and structured techniques. More than once the enforcement of structured thinking allowed greater flexibility in both modification of on-going work and in the location and elimination of errors.

Can learning be fun? After only three months of development, applying the talents of two interested college students, the foundation and the framework has been established for MELBORP, a drill and practice system for kids.

Project Reports

LEARN

Barbara Kurshan - Hollins College

LEARN is a project to develop an on-line tutorial to teach potential authors how to use the Teacher Interactive Computer System (TICS). The tutorial is being developed and tested at Virginia Tech on the Honeywell MULTICS Time-Sharing System. TICS is a Computer-Assisted-Learning (CAL) language which facilitates the authoring of interactive computer programs. A team at M.I.T. headed by Professor Roy Koplow developed the TICS author and delivery system in 1971.

Since TICS was developed its use has minimal; perhaps due to its lack of related educational materials. Therefore, Project LEARN's primary objective is to provide sufficient instruction to teach authors how to write CAL programs with TICS. The program consists of two instructional parts, a set of laboratory exercises to coordinate with an on-line LAB and a LEARN Guide. Part I teaches how to create output to the learner in a node; accept and analyze responses; run a simulation of the tutorial; and describe node behavior. Part II contains descriptions and examples to teach: advanced TICS commands; the dictionary facilities; special nodes; and author facilities. The LEARN Guide provides an outline of the tutorial, the procedures for using the tutorial, the lab exercises and work-sheets and a listing of the TICS command formats.

LEARN was deisgned to be educational, motivational and to serve as model for other academic tutorials. It is being tested and evaluated by a group at the Virginia Tech Computer Center. The evaluation criteria are designed to analyze and describe the tutorial development time, learn time, interest level and error correction. After the evaluation is completed and suggested changes are installed, the program will be available to all users of the MULTICS System.

The PLATO Pilot Project Amsterdam

Dr. Bert Camstra - University of Amsterdam

From October 1977 until July 1979 the PLATO Pilot Project Amsterdam was carried out at the University of Amsterdam. The primary goal of the project was to investigate the potential usefulness of the PLATO system for the whole spectrum of instruction at the University of Amsterdam. To this end, 4 PLATO terminals (later 5) were installed plus some peripheral devices, among which a Gooch music box. Two main lines of activity were chosen, which were denoted as the "depth" - approach and the "breadth" - approach, respectively. In the depth-approach a number of small experiments were conducted with teaching with PLATO, in selected real learning tasks and real students. These experiments were concerned with second language learning (French: vocabulary and irregular verbs), FORTRAN programming for physics students, statistics and mathematics for pedagogy students and ear training for musicology students. Approximately 200 students have participated in one of the about 8 small experiments. The "breadth-approach" consisted of an inventorization and an evaluation of as many existing lessons on as many subject areas as was feasible, on the criterion of applicability within the curricula of the University.

Some selected conclusions.

1. PLATO is an extremely well-designed, well-developed en well-functioning CBE delivery system; as far as we know: by far the best there is.

2. Our Brussel PLATO system has well lived up to the claims of reliability, response time, etc., in short: the technical dimension.

3. Generally, in our experiments students seemed to learn the same 'amount' of learning as with their conventional conventional procedures, in 50% of the time. In some of the experiments, gains were higher with PLATO at the same time.

4. It is much more difficult to obtain acces to unpublished existing lessons on other PLATO systems than was anticipated, and the fact that CDC has chosen to organize an extensive "publishing mechanism" for courseware is a contributing factor to that deplorable state of affairs.

5. The value of the alleged enormous quantity of existing courseware is only marginal for Dutch universities. Only a fraction of the lessons can be used "as such", another fraction could be used after adaptation and the majority cannot be used at all.

6. Instruction via PLATO seems particularly suited for the adaptation to specific deficiencies in students and in the capacity of remedial teaching.

7. For instruction via PLATO to be really effective, it must be extremely well geared to the specific instructional situation, which implies local lesson development in nearly all cases.

8. Dutch students accept PLATO with a fairly matter-of-fact attitude: they do not generally have negative preconceptions and are fairly positive, to a fair extent concomittant with the quality of their instructional experience with PLATO.

Coordination of Computer-Based Instruction (CBI) Efforts

in Federal Civilian Employee Training

James A. Everett - Training Consulting Div.

Unlike their military counterparts, Federal trainers in civilian agencies are in a very early stage of state-of-the-art assessment and implementation of CBI. Civil agencies that "go it alone" usually lack the large numbers of employees with common training needs that would make CBI clearly cost effective. However, if the needs and resources of all agencies are aggregated, cost effectiveness can be facilitated. Scarce CBI resources can be shared to broaden capability and to prevent under-utilization. Duplication of effort can be avoided.

In this project, the Training Consulting Division, Office of Personnel Management has launched several efforts to bring about coordinated CBI implementation across civilian agencies:

a. Formation of an Interagency CBI Study Group whose membership is CBI technicians and program managers in agencies that already have active CBI projects. This group shares project and state-of-the-art information, and informally assists each other in a variety of ways.

b. Formation of a CBI Resource Coordination Group whose members have governmentwide policy or leadership charters that impact on CBI (and other computer applications). Member agencies include OMB, OPM, GSA and several others that represent the many different jurisdictional elements involved in CBI (e.g. training; data processing; telecommunications policy; fiscal; procurement). This group works on coordination of government-wide policy and procedures with an objective of enhancing cost effective CBI applications and removing bureaucratic impediments.

c. Formation of a "Center" for acquiring CBI services. Under this concept, Federal agencies may obtain most private or public sector services through OPM, which maintains the necessary resources "on call" through on-going contracts and/or Agreements with agencies that have underutilized capability. This service is expected to encourage CBI applications by providing dependable, responsive, expert assistance to agencies at reasonable cost.

The Incorporation of Computer-Based Learning Tools in Teaching at the Open University

Aldwyn J.R. Cooper - Open University

The Open University provides degree level education for more than sixty thousand students in a wide range of subjects. All the teaching is accomplished 'at a distance'. Tuition is by means of radio and television, correspondence-texts, further reading material, home-kits and some measure of face to face tutorials provided at local study centres.

Simple computer marking of assignments has been a feature of the university's practice since its inception ten years ago. However, the limited information available to the students from basic grading has been found to be unsatisfactory. During the past four years the university has instituted a number of projects to use computing in a more innovative and valuable manner to supplement existing facilities. The applications currently in use include, diagnostic testing and remediation, tutorials, semi-automated tutorials, counselling and improved assessment and feedback. Most of the systems are either available interactively through the Student Computing Service nationwide network or can be accessed, albeit in a limited form, by post using a batch system.

Some twenty thousand students now have the opportunity to use the system on courses which span the university's full educational range. Some studies have been carried out on the take-up rate of the facilities across various courses. Information form these will be reported and there will be a brief discussion of the reactions of the staff and students to the various systems.

Currently, the university is investigating ways of bringing computing power into the students homes, either through applications of the British Post Office Viewdata system (to be called OPTEL within the university) or by the provision of home computing kits. Progress in this direction will be reported.

CAI and General Education: A Pilot Study

Edward L. McGlone - Southern Illinois Univ.

John M. Eddins - Southern Illinois University

Our project is based on three notions about computers which have been talked about for years: 1) that a good CAI system (like PLATO) is essentially a communications system, 2) that every educated person ought to know how to "use" computers, and 3) that some college-level subject matters can be taught totally online, that is, without any classroom experiences or activities. We know of no previous attempt to implement and test these ideas in a single project.

In August, 1979 we began a two year pilot project to teach a course entitled "Computers and Communication," entirely online using PLATO. The course was approved on an experimental basis to be listed among the other general education courses in the communication area. (These other courses include mathematics, English composition, and speech communication.) The single difference between this and the other core courses is a limitation of enrollment because of the availability of terminals.

Students who enroll in the course are oriented to the PLATO system in a half-hour session, given author signons, and told to complete a few specific lessons introducing them to the PLATO system. They are told that the two purposes of the course are to enable them to master a communication system, viz., PLATO, and to use that system to assist them with other educational and personal goals. The students are then left on their own with the advice to spend about two hours a week online and to ask questions online via personal notes to the instructor.

We are convinced that the course was a sound educational experience for the first group of students and we are hopeful that the project will demonstrate considerable value for our approach. While the students did not "see" the instructor for the most part during the course, the quality and level of instructor-student interactions were judged excellent by all parties. The students mastered the usual PLATO lessons and skills which pertain to communication, such as terminal talk and monitoring, private and public notes, authors and users lists. Each was able to find a number of lessons helpful to his or her individual studies even though their majors ranged from cinema to speech pathology. We did not encourage lesson-writing although several completed introductory lessons in online editing and TUTOR language programming. There was considerable intraclass communication via personal notes and terminal talk, and the sharing of ideas and information reached the point where nearly every student was sending notes to the instructor in online animation, even though the lessons necessary to acquire this skill were normally not available to the students. In several instances, students contacted authors at other sites in order to locate lessons of interest. The number of hours of online experience for individuals in this first group of students ranged from thirty to more than a hundred during the semester.

Pre-Calculus Mathematics with PLATO Support

Ronald H. Wenger - University of Delaware

Keith Slaughter - University of Delaware

I. Structure of the Course

Math 115 is a new course which covers algebra and elementary functions in one semester. It's primary objective is to prepare students for calculus but a large number of students take this pass/fail course as a final mathematics course required for their major. Approximately 1100 students per year enroll in it. Virtually all of them are freshmen. Each week students attend two lectures (limit 150) taught by a faculty member and two workshops (limit 25) handled by under-graduate teaching assistants. All classes are fifty minutes long. The course is divided into four "modules" of approximately 3 1/2 weeks each. To pass the course students must pass all four modules or three of the four and a comprehensive examination. To pass a module a student must receive a grade of 70% on one of two attempts scheduled one week apart. All students in the course in a given semester take the same multiple choice examinations.

II. PLATO Workshops

During the fall semester 1979, an experiment is underway using PLATO terminals in some workshops. Four examinations per module administered in previous semesters and their answer keys are available in a Sample Exam Test Booklet. The problems from these same examinations plus one other test per module are available on PLATO together with solution steps. They may be accessed by one of three options:

1. Specific Problem Mode. Students may examine solutions to specific problems in the Sample Exam Test Booklet.

2. Practice Problem Mode. Students may select one or more sections from their text and choose to see all problems in random order from the tests which correspond to these sections or only such problems which were answered incorrectly by more than half the students who took the test on which they appeared. After attempting each problem students may see its solution in a few steps.

3. Test Mode. Students may take a full test under timed test conditions. The problems from one of the five tests per module on PLATO are not available in the Sample Test Booklet nor in the modes above so that the student can try a "clean" test. Solutions are not available until test completion.

III. The Investigation

Three "traditional" and three "PLATO" workshops associated with one large lecture are being studied. Each of three undergraduate T.A.'s teaches one workshop of each type. The backgrounds of students in these sections at entry are being assessed by traditional methods.

Performance on Math 115 in-class examinations will be examined. We are attempting to determine performance differences among students in PLATO workshops and traditional workshops. Student attitudes towards PLATO use are also being collected.

Findings will be reported at the ADCIS Conference.

Comparing Three Cal-Delivery Systems

Jef Moonen - University of Leiden

Since 1975 a CAL-system is operational for the statistics course of the Department of Psychology of the University of Leiden. The system is written in APL and runs on the IBM 370/158 of the Computing Centre of the University.

Although the Computing Centre supports the CAL-project, a recurrent problem is how to come to a fair division of computing time and other facilities between educational, scientific and administrative users. If not enough attention to the organization and distribution of the central computing facilities is paid and if one is not deeply involved in such a project, the risk to be set aside by others, is very high. Experiences elsewhere show that CAL-projects often parish in this struggle. Considerations of this kind were the first reason to look for other delivery possibilities for CAL-programs. The second reason to look for alternatives was the present availability of microcomputers and of other, more dedicated computer systems for CAL. As not much is known as yet about the advantages and disadvantages of the presently available delivery systems, a project has been set up to investigate these other possibilities. In this project the existing CAL-system will be compared to the same CAL-system running on a IBM 5110 microcomputer (with diskette unit) and the one running on the PLATO-system.

Within the project the following activities are planned:

- Conversion of (a subset) of the existing CAL-program to the IBM 5110 and to the PLATO-system, such that the specific and special facilities of each configuration are used in an optimal way. Of course, the different constraints that are met within each configuration are taken into account. For the IBM 5110 this means working in a workspace of 58K bytes instead of 168K bytes on the IBM 370/158 machine, and having problems of rising access time and response time. For the PLATO-system this means that big problems in imitating the enormous flexibility available in APL has to be overcome.

- To gather facts and figures about the conversion jobs, especially with respect to the use of a general purpose language(APL) versus an author language (TUTOR) in developing CAL-programs. The problem is widely known and most of us have pronounced ideas on these matters. It may be a good experience to write the same CAL-progam in different languages, and have it run and used by students, so that by comparing results a more objective standpoint can be reached.

- To get detailed information about the performance and attitudes of students working with the different systems. An often heard criticism of the PLATO-system says that a number of those wonderful features available are not used in the program and/or if used, do not make any difference to the student.
Earlier [1] we have investigated the influence of the use of CAL on the performance and attitudes of students, in comparison with a curriculum organized in a more traditional way. We now want to investigate the possible influences of a specific CAL delivery system on students' performance and attitudes. Therefore a controlled experiment will be conducted comparing the following configurations:

- CAL running on a IBM 370/158 using IBM 2741 terminals
- CAL running on a IBM 370/158 using Textronix 4015 terminals
- CAL running on the PLATO-system
- CAL running on a IBM 5110 microcomputer.

If these comparisons do not indicate a significant difference with respect to performance and attitudes of students, the choice of the specific CAL delivery system will be determined

exclusively by external (not educational) criteria, it is clear that most of them can be brought back to the costs of the system.

Results of the different aspects of the project will be presented during the conference.

Advanced Accounting

Angelo E. Di Antonio - University of Delaware

I. Structure of the Course

Accounting 415 is a required course offered to accounting seniors. The course covers a variety of subjects including partnership accounting, fiduciary accounting, corporate combinations, corporate consolidations, installment sales, consignments and accounting for multinationals.

Four sections of Advanced Accounting are usually taught in both the Spring and the Fall semesters. The classes are limited to 25 students. Common examinations are administered to all sections at one sitting. The course is segmented into four modules with an examination given after the completion of each module. The conventional lecture, textbook and examination format is used for the course.

II. PLATO Classes

During the 1979-1980 academic year we are conducting an experiment using PLATO terminals in Accounting 415. Three sections are taught by one instructor and a fourth section is taught by a second instructor. The fourth section is an evening section and consists of many part-time commuter students.

The three sections with the common instructor are serving as the basis of our experiment. These sections meet on Tuesdays and Thursdays for 1 1/2 hours each day. At the beginning of the semester, the students were supplied with a syllabus listing assignments, the name of the textbook and the basis for grades. The students were also apprised of the format of classroom instruction. Throughout the semester, Thursdays were devoted to the conventional lecture mode. On Tuesdays, the class was assigned to the PLATO "classroom". There are 25 PLATO terminals in the classroom. With our enrollment limit of 25 at the senior level, class size does not represent a problem. Each student has a terminal available for their individual use during the class session.

The material from the textbook in use was adapted to the PLATO PLM system. The PLM system provides for a complete module including objectives, instructional units, objective items with a variety of formats, mastery and non-mastery feedback, etc.

III. The Investigation

We are primarily concerned with the affective domain with this effort. Students contract a disease called "senioritis." Can PLATO help with this problem?

REPORT FOR: CMIS NATIONAL NETWORK 1978-80

Dr. Robin D. Avery-Macomb County Community College

Network Description and Purpose: To develop, demonstrate, and refine a Cooperative (Education) Management Information System (CMIS) Model for use in institutions of higher learning, business and government. A basic assumption of the design is that it will provide managers and other co-op practitioners with the methodologies to determine the appropriate information-gathering and/or other evaluative instruments to: 1. accurately describe their local environments: 2. measure the effect of the co-op experience on students, schools and industry; 3. assess the longitudinal impact on students' career development; and 4. systematize the evaluation of their programs to increase their overall effectiveness.

Background and Need: From 1906 to 1960 the growth of Cooperative Education programs in higher education had been slow to moderate. During that period the ability to regulate program activities, evaluate co-op interaction in industry and education, and plan for gradual program growth was demonstrated by various educators and business leaders nationally. However, as more institutions developed co-op programs in the '60s and '70s, the amount of information generated became staggering. Hence the need for a larger framework for the management of information has become apparent at all levels of co-op participation: educators, students, industry management, government officials, and other interested community members.

Progress to Date: From August, 1978 to July, 1979 the CMIS model was developed and fieldtested at MCCC. During that period it was demonstrated regionally and nationally. By September, 1979 the initial national network was chosen and now includes: Macomb County Community College, Xavier University (LA), State University College (NY), St. Mary's University (TX), Eastern Kentucky University, Lexington Technical Institute (KY), University of Wisconsin, University of Minnesota, and East arolina University. A workshop was held at MCCC in October, 1979 to in-service all network personnel and begin model implementation at all test sites. By August, 1980 final national documentation will be completed and plans for network expansion (exportation of the model to other co-op programs nationally)will be finalized.

University of Delaware Honors Program

Morris W. Brooks - University of Delaware

The University of Delaware Honors Program accepts each year a group of about 200 students of exceptional academic ability into its full-time freshman program. About 40% of these students are admitted at the end of their junior year of high school, making this the largest early-admit program in the country. Characteristic of the program are small class size, close personal contact with faculty, and use of innovative and experimental methods of instructions.

More than 2/3 of the students in this program study calculus and I have taught classes at each of the three levels of the basic sequence. For the last two years, I have used the Delaware PLATO system to enrich the curriculum of these courses and have developed and programmed a number of PLATO lessons designed for use by these students.

PLATO has been used in these courses to provide:

1) remedial instruction for students of deficient background;
2) drill and practice in basic skills of differentiation, integration, etc.;
c) access to the computer as a tool for implementing numberical algorithms, i.e., root-finding, approximation of definite integrals, etc.; and
d) a sophisticated interactive computer graphics capability allowing students to explore on their own the various relationships between geometry and the properties of the elementary functions.

The first three are fairly standard. The last is most interesting. I use several PLATO lessons which allow plotting of geometric figures as specified by student supplied functions. These include cartesian, polar, and parametric curve plotters, a vector-field plotter, and a surface-plotter. Several allow the option of storing examples in a catalog which can be accessed by others in the course. The variety and beauty of their efforts is impressive.

Brockport Science and Mathematics Microcomputer Project

Dr. Theron Rockhill - SUNY Brockport

With support from the NSF-CAUSE Program, science and mathematics faculty at Brockport are developing instructional modules which utilize microcomputers (APPLE II + systems) for modeling, simulation, data analysis, and problem solving. Each module consist of an interactive BASIC computer program, a student guide and an instructor's manual. Materials are currently being developed in mathematics, Biology, Chemistry, Earth Science, Geography, Physics, and Phychology.

CAI in Pharmacology at the University of Alberta

Charles Heath - University of Alberta

Louis Pagliaro, Charles Bidwell, David Cook

This paper describes the initiation, implementation and evaluation of a project to introduce CAI as an integral part of pharmacology teaching. Since 1977 more than 50 lessons have been edited and run on nine terminals connected to an Amdahl 470 computer. The lessons are used by more than 300 students in Medicine, Pharmacy, Dentistry and Science.

In 1971, an IBM 1500 system owned by the university's Division of Education Research was used to run four lessons. These gave encouraging results and in 1977 pharmacology lessons developed by the CATS Consortium were extensively revised and made available to a wider group of students. These were again revised and additional ones were written. Some of the lessons were translated into PILOT or BASIC and run on three SOL microcomputers.

Virtually all students tried CAI, with some spending as little as 30 minutes and others over 20 hours. Most students were enthusiastic about the approach although a few preferred other methods of learning. In a controlled study now in progress the effectiveness of this approach vis a vis traditional teaching is being examined. In addition an attempt is being made to correlate student characteristics (using California Psychological Inventory) with success in CAI.

A LOW-COST MICROCOMPUTER MUSIC THEORY LAB

Arthur B. Hunkins - University of North Carolina

Demonstration of an under $1000 music theory drill lab consisting of an 8K Commodore PET microcomputer, D/A converter board, and audio monitor. Featured are the use of low-resolution PET graphics for music staff notation, and a four-voice machine language sound program. This cassette-based system of twenty-one series of pitch notation and ear training drills is intended for supplemental work in high-school and college level traditional music theory classes. Individual drills are limited in scope, and highly specific in content, in contrast to more generalized, high-power approaches. In the area of pitch notation, these cassettes aid in recognizing single pitches (in various clefs and transpositions), intervals, key signatures, scales, scale degrees, triads, and seventh cords. In ear training, the series offer drill in absolute and relative pitch, intervals, scales, scale degrees, triads, seventh chords, melodic contours, chord progressions, as well as in a non-traditional but essential area, intonation. Programming is in BASIC. Level of difficulty is selected by the user, and a number of user options are available during program runs. A master catalog cassette is available, and series program descriptions are included at the beginning of each tape, in the directory program. Loading and running of tapes is as simple as possible, in order to minimize user frustration and error.

PATTERN RECOGNITION FOR AN EDUCATIONAL PLACEMENT SYSTEM

D.H. Dugre, M.D. Johnson, W.J. McInery,
City College of San Francisco

M.O. Naumann, S.A. Barger, B.A. Coyle
City College of San Francisco

The means we have traditionally used to diagnose student unpreparedness and accordingly to adapt sections of our courses to remove this and to prepare them for subsequent learning have consistently had results with unsatisfactory features. In an effort to reduce the costs, institutional, societal, and especially personal, that accrue from inappropriate diagnosis counseling and placement, we have made the beginnings in devising and implementing a computerized system which we call PREPS. It entails for each individual student upon entering a course: the collection and analysis of information, the identification of preliminary performance with pieces of this information (diagnosis), and placement in a section optimally tailored to his or her needs (prescription). Pattern Recognition techniques have been chosen for utilization in the analysis phase because: (a) they are free from a priori assumptions and prejudices about predictors of academic success; and (b) they guarantee a successful, detailed diagnosis when adequate variables are chosen. This study thus has found a novel use for Pattern Recognition, whose applications are many in diverse fields, and more specifically form a most important section of modern chemometrics. The pattern space is spanned by vectors, the components of which are both demographic (age, time since previous study, etc.) and academic (prerequisites satisfied, performance in tests, etc.) variables.

COMPUTER-ASSISTED EAR-TRAINING PROJECT AT LAVAL UNIVERSITY

Martin Prevel - Universite Laval

Previously based on the exclusive use of Laval University's time-shared computer system, our work is now oriented toward the use of a low-cost microprocessor-based student station for the delivery of ear-training exercises.

Rather than developing sequential and progressive lessons, we wanted to give the students standard exercises which they could tailor by using a set of pre-determined commands which vary the parameters of the standard exercises. Two important principles have also given direction to our work. The first involves finding the most effective rate of interaction in order to maximize the number of questions asked in a single training session. The second, for its part, involves replacing, insofar as is possible, visual feedback with auditory feedback which, as a means of pedagogical communication, appears to conform the most to the learning objectives in music.

As an example, several lessons will be demonstrated, firstly, conceived on the basis of the aforementioned objectives; and secondly, conceived on the basis of the characteristics of the minimal student station which we have developed specifically for its low cost, enabling our school to extend computer-based ear training to all students.

The Center for Music Research at the Florida State University

Jack A. Taylor - Florida State University

The School of Music at Florida State University has initiated a Center for Music Research (CMR) this year which mates the already existing Experimental and Electronic Music Laboratories to a PLATO system. CMR's goal is to create maximum man/computer environment for the experimental study of the music phenomenon as perceived and manipulated by humans. Initially, the CMR will be dedicated to basic research in music perception, memory, and the aesthetic and cognitive processes of music composition and performance.

Long-range plans include the development of prototype music hardware and software; and at the conclusion of a five year period, the CMR will complete the Integated Cybernetic Music System (ICMS), a comprehensive collection of music hardware interfaced to a general music data base that resides in the PLATO system (see attached figure). Both during and after the development period the School of Music intends to invite performing musicians, composers, researchers, and computer specialists to utilize the resources of the CMR and to contribute to the development of the ICMS.

Completed (or almost completed) CMR units are (a) Electronic Music Studio consisting of a Moog synthesizer and multitrack recording facilities; (b) Experimental Laboratory with professional quality acoustical and audio equipment, including a microcomputer with dual disk drives and line printer; (c) Software Laboratory with two PLATO terminals (IST2 and PPT) and a matrix printer; (d) Wood and Metal Shop; (e) End Product Laboratory, including eight PLATO IST2 terminals with four-voice synthesizers (Gooch Synthetic Woodwind); (f) Offices and Seminar Room. This year a digital melody programer with parameter readouts was completed, and other prototypes well underway include a performance console with a "dynamic" (touch-sensitive) keyboard and a "pitch extractor" that listens to pitches produced by voice or instruments.

With the addition of an Electronics Shop and full-time hardware and software specialists in the Summer or Fall of 1979, the CMR will be in full operation. Current part-time personnel include a Director, Associate Director, Secretary, Woodshop Specialist, and Programer.

Performance-Related Enabling Skills Training (PREST)

Shirley C. Smith - Research for Better Schools, Inc.

In order to meet the specific recruit-literacy development needs of the U.S. Navy, Research for Better Schools, Inc. (RBS) is developing a computer-based job-related reading skills curriculum for recruits who enter the service reading at less than a sixth-grade level. The curriculum has been names PREST (Performance-Related Enabling Skills Training) in order to emphasize its focus on the development of Navy functional literacy skills. A computer-based curriculum was chosen because it appears to offer the best hope for cost-effective delivery of a quality reading program to large numbers of recruits.

PREST utilizes the basic management system and the reading components of Control Data Corporation's (CDC's) Basic Skills Learning System (BSLS), a computer-based instructional program designed for use with adults reading below the eighth-grade level and delivered via CDC's PLATO terminal. This particular program was chosen because it has been proven effective for use with adult populations (in adult learning centers, public schools, and correctional institutions) and because its objectives correlate well with those established for use in the remedial reading instruction of Navy recruits. (The reading component of BSLS consists of five sections, one to represent each of the five major reading skills: structu-al analysis, vocabulary development, literal comprehension, interpretive comprehension, and evaluative comprehension.)

PREST also includes a special strand of Navy-related study skills modules which have been developed by RBS to aid recruits in meeting the academic demands of their training program.

In addition, a set of off-line Navy job-related materials has been developed to supplement each of the 118 lessons which are delivered on-line.

All recordkeeping and management of recruit progress is handled by the computer and this information is readily available on-line for review by the instructor or other authorized personnel.

This program is being field-tested with approximately 100 recruits at the Navy Recruit Training Center in Orlando, Florida during February, March, and April of 1980.

FSU PLATO Project: Basic Skills in Math for Florida High Schools

Janis E. Qualls - Florida State University

During the 1978-1979 school year, a pilot project was conducted at three Florida high schools utilizing the PLATO system to deliver remedial mathematics instruction to those students scoring lowest on mathematics portions of the state assessment test and district achievement tests. The courseware used in the project was the mathematics component of Control Data Corporation's Basic Skills Learning System. The major purposes of the pilot study were to 1) determine the operational feasibility of remote PLATO sites in high schools, 2) field-test the mathematics courseware employed in the classroom, 3) provide data showing PLATO's effectiveness in remedial math instruction, and 4) provide an economic analysis for using PLATO in public schools.

The project was funded by Florida State University (FSU) and Control Data Corporation. Each of the three schools contributed one mathematics teaching position. The schools, located in Duval, Palm Beach, and Sarasota counties, were targeted for their representation of an urban, a suburban, and a rural population. Each was equipped with eight display terminals connected to a central computer at FSU.

Students were tested in September and again at the end of each semester using the mathematics portion of the Adult Basic Learning Exam (ABLE) Level II. Evaluation data for the school year revealed an overall median gain in mathematics for 236 students of 1.5 grade levels after spending an average of 20 hours in the PLATO math lessons. Seventeen students completing the curriculum at one test site went from a median pretest grade equivalent score of 6.0 to a median posttest grade equivalent score of 9.0 after spending an average of 35 hours in the lessons. Student attitudes towards PLATO remained positive throughout the year. Attitudes toward mathematics and school, which were positive at the beginning of the study, were more positive at the end of the year. Administrators and teachers were very enthusiastic about the academic growth of the students and the eagerness of formerly apathetic students to attend class and to learn.

Producing Music Notation by Means of Programmable Characters

Dr. Leslie Kleen - Ohio University

For the institution which cannot afford expensive graphics terminals using storage tubes or plasma displays, one of the most inexpensive methods of graphically producing music notation for computer assisted instruction is by means of a micro-processor which includes programmable characters.

Conventional music notation is in part graphic, but essentially consists of a limited number of symbols which are constant in form. Since these symbols are not limited in shape to the dimensions of an alphanumeric character, they are formed by combinations of programmed characters.

We are working with a micro-computer that has a 1K RAM section above the ASCII character ROM in which the 8 X 8 bit patterns of 128 characters may be created and stored. These characters are assigned ASCII values 8Ø hex to FF hex. Treated as an extension of the ASCII character set, these special characters may be placed directly in print statements and may be processed by the string-handling functions of BASIC and PILOT. This also allows music notation to be efficiently transmitted along communication lines as from a large host computer to remote terminals. And, by using the graphic and shift keys, all characters may be accessed directly from the computer keyboard.

Not all music symbols can be produced from a single set of 128 characters, so we have designed several sets for particular applications. The notation is most efficiently produced when the height of one space of the staff is equal to one character (8 points) or 1/2 character height. The former allows 3 full staves, and the latter, 6 staves on the CRT display. Also, spacing of musical symbols in the horizontal direction is in multiples of the character width. Since there are 64 characters per line, this has not proved to be a severe limitation.

Despite the relatively high resolution (512 X 240 points) for CRT-produced graphics, no additional RAM is required for the video display. Text and graphics may be combined in any manner, and there is no mode shifting between alphanumerics, plotting, or high resolution. Since musical symbols are produced by combining several characters, the notation-producing software is quite compact.

CASIM: Computer Access to Self-Instructional Materials

A. Roberti, D.H. Dugre, B.A. Coyle

City College of San Francisco

CASIM is a database system designed to facilitate the classification, location, and integration of self-instructional and self-testing materials into both the instructional program and independent study at City College of San Francisco. It attempts to address common access and record-keeping problems, which are often exacerbated by the dispersion of materials to different locations and the lack of standardization of cataloging procedures, as well as the limitations of traditional card catalogs. CASIM provides multiple capabilities and benefits for students, instructors, collection managers and the institution.

City College of San Francisco serves an extremely diverse and large clientele, offering over 1200 courses through 88 departments to an average daily attendance of over 17,000 students. The College has extensive collections of self-instructional materials held in various locations. Because of the variety of student skills, compentencies, and interests, and recent growth in the number of individualized and mastery-based courses, the need for improved access to self-instructional materials became evident. Current fiscal constraints also mandate maximum utilization of existing resources, non-duplication of purchases, and careful delineation of spending priorities.

It is hoped that CASIM will serve as a model for similar databases at other sites. The project participants are unaware of the feasibility, or desirability, or present extent of inter-institutional sharing or loaning of self-instructional materials. However, CASIM-like projects could form the basis of a Union List of Self-Instructional Materials to facilitate such cooperation. Thus, there would be a directory of all such resources available for loan or duplication. Since the cataloging information would already exist in machine-readable form, it could be readily sent to other institutions, thus saving significant amounts of cataloging and data entry efforts.

USE OF PLATO IN DEVELOPMENTAL ENGLISH

Sue-Kemner-Richardson, Neil Ashby,

William MacGregor - University of Colorado

During the Fall of 1977 and again during Fall 1978, the University of Colorado School of Arts and Sciences decided to employ PLATO in the instruction of freshmen who were found to need remedial instruction in English composition. These students were selected because they scored below the national mean of entering freshmen in composition skills.

During the Fall of 1978, an evaluation was undertaken comparing the effectiveness of PLATO as an instructional resource to the effectiveness of 25-student classes taught traditionally by individual teachers. In the PLATO experimental classes, students met with their professor one hour per week in lecture sections of 125 students, and were also assigned to one of seven readers, who corrected weekly compositions and made lesson assignments on PLATO (one hour per week per student). The students worked to remediate their individual problems in writing as error patterns were identified by the readers' marks on student papers. The error patterns were related to sets of grammar-oriented exercises on PLATO. The professor's role was to tell the students what to write and how to do it, the role of the readers was to tell the students what each of them was doing wrong, and the role of PLATO was to help the students correct ("remediate") their identifiable error patterns. Approximately 250 freshmen received the PLATO treatment for a 16 week semester.

The control group was composed of freshmen scoring at or above the national mean on a standardized composition test. Students in both groups were required to write a short composition at the end of the semester which was objectively socred for number of errors by category (diction, syntax, etc.). After completion of the tabulation procedure, the number of errors per 100 words in each composition was computed. The comparison to be drawn was between pre-treatment composition scores on the ACT and SAT composition subtests and post-treatment composition error rates, taking into account predicted regression.

A regression analysis was preformed in which the scores on the pre-test were used to predict scores on the dependent variable, the final composition error rate. The regression lines for the two groups differed significantly (p less than .005). The slower group benefitted much more from the experimental treatment than they would have from the traditional treatment. Reciprocally, the control group (students needing no intense remedial instruction) appeared to have benefitted more from traditional instruction.

An Evaluation of Three Modes of Practice Music Interval Construction

Barbara Murphy - The Ohio State University

In this study, I examined which of three methods of practicing best facilitates learning the concept of music interval construction by freshman music theory students. The three methods of practice considered were self-practice (SP) using text information from Edward Aldwell and Carl Schachter's Harmony and Voice Learning, Vol. I, linear programmed instruction (PI) using John Clough's Scales, Intervals, Keys and Triads, and mastery learning using a CAI program (CAI/ML) which I designed for this study and wrote in the Phoenix computer language. Also considered was the variable of retention of the learned material over time, either immediate or delayed (24 to 48 hours).

All freshman theory students at The Ohio State University in the Fall of 1979 were given a pretest consisting of thirty music interval questions. Eighty-seven students then signed up, at random, for a session in which to study interval construction for approximately one and one-half hours using one of the three modes of practice. They were then given a post-test of thirty interval questions and also completed an attitudinal survey on whichever practice method they used. After a 24 to 48 hour delay, the students were again given the same thirty question post-test on intervals.

The results of the pretest, using a one way analysis of variance, showed no significant differences among the three groups. However, the post-test scores, analyzed by a 2X3 ANOVA-R formula (two within-subject and three between-subject variables), showed a significant difference among the three modes of practice ($p=.002$) with the CAI/ML instruction proving to be best. Also, retention of the material was found not be be significantly effected by the amount of time delay between study and post-tests ($p=.145$) or by the interaction of method of practice and time delay ($p=.802$). An ANOVA was also calculated for the attitudinal mean scores and showed a significant difference ($p < .0005$) between the SP, the lowest score, and PI groups and between SP and CAI/ML methods while showing no difference between the PI and CAI/ML groups. Correlations were also calculated on the attitudinal survey scores for each possible combination of the three methods of practice. The results showed negative correlations between the PI and SP groups and between the CAI/ML and SP methods' attitude while the correlation for the PI and CAI/ML attitude socres showed them not to be significantly different.

Computer Assisted Instruction

A Program In Calculus and Linear Algebra

Brian Wesselink - The College of Charleston

The development of a program of computer assisted instruction at the College of Charleston began in the Spring of 1978 with the support of a Local Course Improvement grant from the National Science Foundation. Most of the Calculus and Linear Algebra modules in this program are of two types, testing and a combination of drill and practice and tutorial. Since data on student use of these modules is currently incomplete, this report will summarize the program and the types of modules which are available. Data will be presented at the ADCIS meeting.

CAI modules are written in an extended version of BASIC and may be run only under computer program control. Each student using these modules is assigned a computer account from which only the CAI modules can be accessed. After logging on the system, a subject area menu is displayed, followed by a menu of modules for the subject area selected by the student. At any time during the session, the student can return to the subject menu to select another module or to log off. No knowledge of programming or of the computer system is required.

Testing Questions in each testing module are randomly selected from a question bank, each question being either true-false, multiple choice or short answer. Possible multiple choice answers are also presented randomly. Responses to each question (except for non-numeric short answer questions) are checked, and feedback is provided to the student. Students can be given more than one opportunity to give the correct response before the answer is displayed. All student responses are retained and are used to determine the suitability of the questions and to provide instructors with information on students' weaknesses. At no time are these tests used to grade a student's performance.

Tutorial/Drill and Practice Problems in these modules are generated randomly, minimizing the chance of the same problem being presented to the student. Each module is designed to maximize the interaction between the student and the program. If a student's initial response to a question is correct, a hint is provided so that the problem can be attempted again. Often several hints are provided before the correct answer is displayed. While these modules were not intended to teach a new concept or technique, many students who cycle through problems and hints are later able to work problems of the same type.

All BASIC CAI programs are designed to take full advantage of cursor control and special line drawing features of the available CRT terminals. Functions within these programs allow for printing mathematical symbols and problems in the same form normally seen by the student.

COOPERATIVE PLATO PROGRAM BETWEEN THE UNIVERSITY OF DELAWARE AND THE NEW CASTLE COUNTY SCHOOL DISTRICT

Fred T. Hofstetter - University of Delaware

Funds have been provided under the Emergency School Aid Act to install 25 PLATO terminals in the New Castle County School District, with five terminals being placed in each of five targeted junior high schools. The main objective of this cooperative program between the New Castle County School District and the University of Delaware is to eliminate racial discrimination and segregation among students and staff while the district undergoes court-ordered desegregation. Through use of PLATO's Basic Skills Learning System underachieving students will receive an individualized remedial program based on the mastery learning model. Not only will the use of PLATO help underachieving students master objectives in the district's curriculum, but it will also develop within the students a better self concept which will enable them to interact with their peers in a more positive manner.

In addition to improving students' self concepts, this cooperative program will also use PLATO's communications facilities to foster interracial communication and multicultural understanding. Students will be able to write personal notes to each other, and they will also be able to participate in group discussions. Small group instruction using the PLATO Basic Skills workbooks will augment the on-line use of the PLATO terminals.

The staff for this project includes a Project Director, five PLATO Learning Center teachers, a PLATO User Services Coordinator, an Evaluation Coordinator, a parent aide, a Program Development Specialist, three student assistants, two graduate assistants, and one clerk. The five Learning Center teachers will work with students using PLATO at the five targeted junior high schools, respectively. The User Services Coordinator will provide in-service training for all staff involved in this project, coordinate the holding of open houses for parents of students involved in the program, and coordinate the installation, operation, and maintenance of the PLATO terminals. The Evaluation Coordinator will be responsible for the evaluation which will be jointly carried out by the district's research office and by the university's Department of Educational Studies. The Program Development Specialist and the student assistants will form a programming team which will design and implement a simulation of the New Castle County desegregation experiences to which teachers who are facing desegregation dilemmas can turn for help in preparing to meet problems in an effective manner by gaining a deeper understanding of the problems of minority students and of the problems of classroom organization in a newly desegregated school environment.

The city of Wilmington's Urban Coalition is investigating the possible use of the district's PLATO services after normal school hours in their eight urban learning centers. Terminals are being installed on an experimental basis during the 1979-80 academic year in three of their learning centers in order to evaluate the effectiveness of PLATO for this application, and if it is successful efforts will be made to expand it to all eight learning centers in the 1980-81 academic year. Parent interest in PLATO is very high as they view it as an exciting learning tool which can captivate and maintain the interest of their children, providing them with an enjoyable experience which helps them learn, feel better about themselves, and make new friends.

A TUTOR to ATS PILOT Translation

John E. Baxter - University of Tennessee

For several years the Computer Technology Branch of the Lister Hill Center for Biomedical Communication has been actively pursuing development of a terminal system that can address, among other things, the interface between the established main frame resident network approach to CBE materials delivery and the currently growing approach of microprocessor facilitated stand alone delivery of CBE materials (1,2,3). The outgrowth of these efforts is the Advanced Terminal System (ATS) (2,3).

As a test of the adequacy of the PILOT language incorporated in the ATS, an attempt was made during the spring of 1978 to translate one instructional lesson from the PLATO Health Science Network Catalog into ATS PILOT. The lesson chosen was one that had been written by one of the authors (JEB) and that had enjoyed continued popularity with student users of the PLATO Health Science Network. The lesson was of the tutorial type that employed extensive answer judging and branching with moderate graphics. The lesson also contained random generation of review questions.

The result of the attempt was a PILOT lesson that encorporated all the judging, branching and randomly generated review questions. This portion of the translation was accomplished with comparative ease. Since the graphics version terminal was not available for work at the time of the project, no attempt was made to translate the graphics sequences included in the lesson. Now that the graphics terminals are available, an attempt is underway to complete that portion of the project. No major difficulties are anticipated.

At least at the level exercised in this project, ATS PILOT has demonstrated itself to be a very capable CAI language.

References:

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A Computer Counseling Approach to Loan Indebtedness: The HEFRI Programs

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The Higher Education Finance Research Institute, located at Pennsylvania's Graduate School of Education, is staffed by an interdisciplinary applied research group committed to serving the entire higher education community through problem solving in economics and in finance. In partial fulfillment toward that goal, by early spring of 1979 several HEFRI employees, under the competent direction of policy analyst Kurt L. Kendis, cleverly developed a set of interactive APL (A Programming Language) programs related to debt management counseling. Debt management counseling by computer represents a novel application of computer-based instruction. This kind of guidance is helpful for prospective or recent college graduates who have incurred substantial indebtedness because of multiple loans made to finance their respective educations. Obviously, optimal candidates for such counseling would be students graduating with doctorates, especially those in the health professions.

More specifically, the HEFRI programs, under periodic revision and extension, include Loan Consolidation, Kendis Plan, Compare Plans, and Model Run. Loan Consolidation is convenient for use in an "exit interview" situation. By way of a continually recurring computer-user dialogue, that program first gathers important information about each loan. Included in this litany are: amount of the loan, length of the borrowing period, repayment options (standard, linear, or exponential schemes), number of years for repayment, number of payments per year, and rates of interest during the borrowing and repayment periods. The machine-human discourse ends after the user inputs his consolidation choice (repurchasing or warehousing) and his estimated starting slaary with its probable growth entered as a percent. The knowledgeable computer then "instructs" the user about his financial obligations by displaying the cash flow for every loan and his entire repayment profile excluding and including consolidation. (It should be noted that consolidation is contingent on the total amount of financial encumbrance and the legal state of affairs. Consolidation is not always possible.)

Since the user must be fully cognizant of the options available in Loan Consolidation, he could first interact with any or all background information programs -- Kendis Plan, Compare Plans, Model Run. These useful programs even supply graphic output. The HEFRI programs, thereby, facilitate debt management counseling totally by computer.